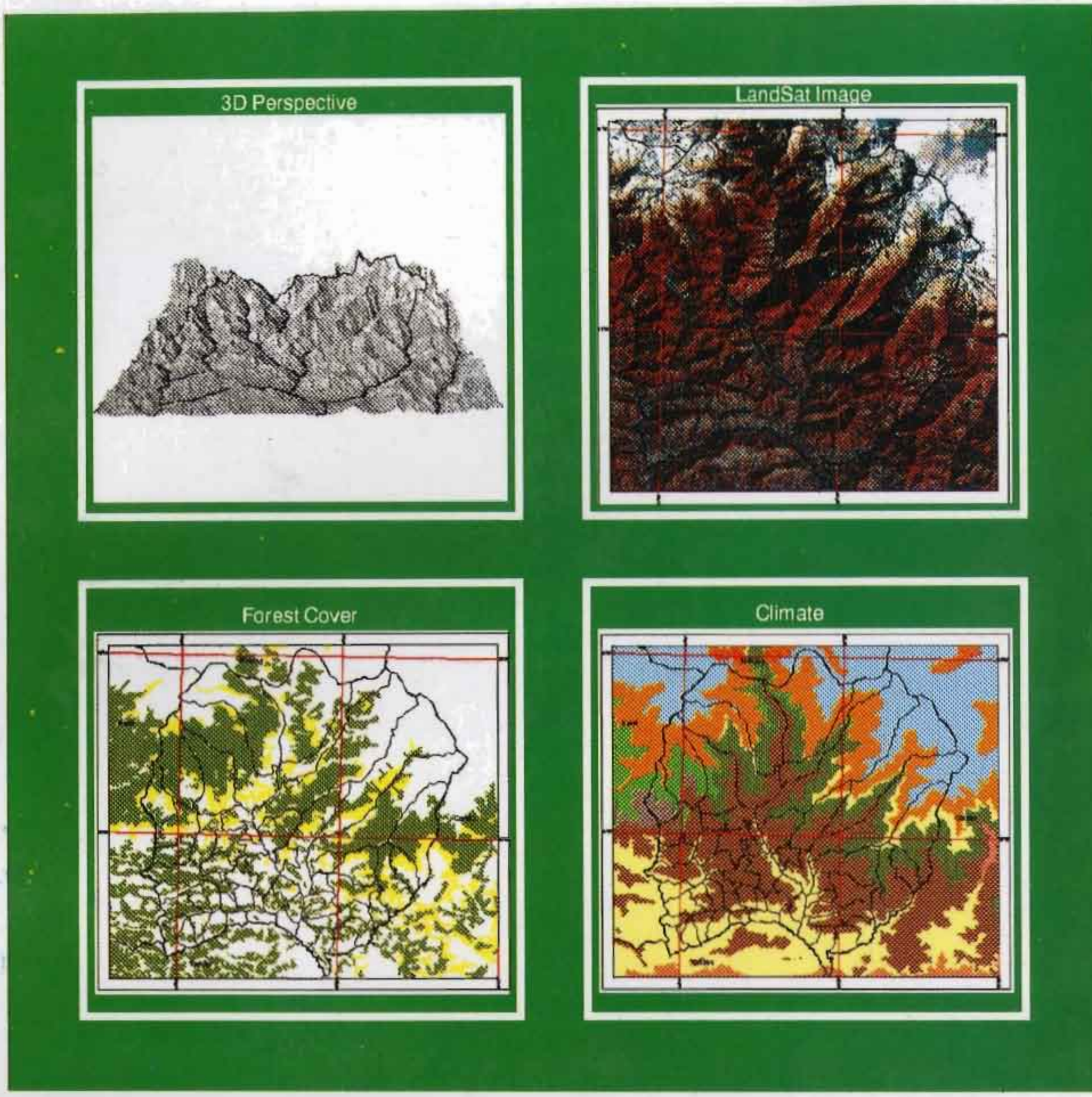
Geographic Information Systems (GIS) and Their Application

Training Manual for Policy-Makers



Mountain Environment & Natural Resources' Information Service (MENRIS)
International Centre for Integrated Mountain Development (ICIMOD)

Environment Assessment Programme – Asia and Pacific (UNEP/EAP-AP)

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Table of Contents

Foreword

As much as 10 per cent of the world's population and a much larger percentage of the world's poor live in mountain regions. Besides those living in the mountains, an additional 30 per cent of the world's population is affected by or dependent on mountain resources and their management. The Hindu Kush-Himalayan (HKH) region itself sustains approximately 150 million people and affects the lives of more than three times that number in the plains and river basins below.

The HKH Region is not only the world's highest mountain region, but also its largest and most complex. It extends over a distance of 3,500 km, from Afghanistan in the west to Myanmar in the east, and ranges from the Tibetan Plateau of China in the north to the Ganges Basin of India in the south.

Due to the difficult topography of mountain regions, their inaccessibility, and lack of an accurate information base, the decision-making process and implementation of development plans often do not meet the desired expectations. The inherent diversity, marginality, and varying biophysical and socioeconomic values present great impediments to the use of Geographic Information Systems (GIS). The ability to design and implement effective policies and programmes in this dynamic environment is dependent on prompt and thorough analyses of current resource assets, their limitations, and changes. The implementation of GIS can be facilitated if the data are collected, merged, and analysed to provide information and output in a form that decision-makers can understand and use.

Geographic Information Systems (GIS) is one tool that addresses the problems of unscientific and inadequate use and management of the natural resources and environment of the HKH Region. The process of using information in planning and decision-making must be institutionalised, and the information must be in a readily available form. This is where a Geographic Information System (GIS) comes into play. It integrates biophysical and socioeconomic data and indicates alternative strategies for decision-makers.

Despite widespread use of GIS in the global context, in mountain environments it is somewhat limited. The implementation of GIS should be considered in a different perspective for mountain regions than in the lowlands. The lack of experience in handling truly three-dimensional GIS, given the prevailing technology, and dearth of trained manpower and accurate multi-sectoral data hinder appropriate application.

Furthermore, the institutional hurdles are greater than the technological hurdles. A complementary approach between various institutions is indispensable for success in implementing GIS.

The technology is gaining increasing importance, because it is estimated that more than 70% of all decision-making processes are either influenced or dictated by some sort of geographic information. The basic advantage of the technology is its ability to manage and perform complex processing of spatial data and their visualisation impact. Without an integrating methodology, identifying viable technological and institutional options for sustainable development of mountain areas is not possible.

Today, a considerable amount of data on the natural resources of the HKH Region is available through satellite, and this is essential for monitoring the ever-changing resource base. Advances in satellite image-processing and computer analysis have made it possible to evolve a realistic, accurate, and uniform database. Resource assessment and monitoring data are becoming widely available and are being distributed in formats affordable even by local resource-planning and management agencies.

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Director General
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Kathmandu, Nepal

Purpose of the Workshop

The purpose of the current workshop is four-fold as follows.

i. to make participants aware of GIS and RS technologies for data analysis,
ii. to brief the participants on how GIS could be used effectively for decision-making and modelling purposes,
iii. to advocate the use of GIS technology for planning purposes and implementation strategy, and
iv. to provide hands-on experience and demonstration on applicability of GIS technology.

Training Module

9:00 - 9:30	Introductory Remarks; MENRIS Activities	Presentation
9:30 - 10:30	Introduction to GIS	Lecture
10:30 - 11:00	***Coffee Break***	
11:00 - 11:30	Implementing a GIS	Lecture
11:30 - 12:00	An Intelligent Infrastructure	A Video Movie
12:00 - 12:30	A GIS Case Study - I	Presentation
12:30 - 13:00	A GIS Case Study - II	Presentation
13:00 - 14:00	***Lunch Break***	
14:00 - 15:00	Hands-on GIS Exercise - Using GIS	Lab Exercise
15:00 - 15:30	***Coffee Break***	
15:30 - 16:30	ArcView - A Management Tool	Demonstration
16:30 - 17:00	Discussion	Exercise

Chapter 1

MENRIS - An Introduction

MENRIS stands for Mountain Environment and Natural Resources' Information Service and is one of the programmes of the International Centre for Integrated Mountain Development (ICIMOD). ICIMOD is the first international agency in the field of mountain development for the Hindu Kush-Himalayan region. It brings together the experiences of the eight countries of the HKH region, as well as experiences from other mountainous regions. Hence the justification for adaptation and dissemination of GIS technology. A regional, coordinated effort towards the establishment of new, or strengthening existing, institutes to take advantage of GIS technology and its applications is essential. It is with this basic objective in mind that MENRIS was established with technical assistance from the Asian Development Bank (ADB) and other support from the ODA, UNEP, GTZ, and UNITAR.

The primary objective of MENRIS is to disseminate GIS technology to ICIMOD member countries through a network of institutions in the HKH region, conduct intensive training programmes, and provide technical back-up. Also, it works to promote and assist information exchange on a compatible GIS platform among the participating regional member countries. Since its inception, MENRIS has envisioned playing a catalytic role in promoting and sustaining GIS and RS technologies through intensive training programmes, networking of institutions in the HKH region, and information base development through partnership initiatives with national institutions.

MENRIS Infrastructure

With available resources, MENRIS has acquired modest hardware/software to facilitate the use of GIS technology. The MENRIS facility consists of IBM RS/6000 workstations and a number of PC-based systems with the latest input/output capabilities. The facility runs in an integrated networked environment, with IBM AIX and DOS/Windows operating systems, to fulfill the following purposes.

- GIS Application Development
- Training Centre
- Data Input Activities
- RS and Image-processing Applications

The support from ESRI to provide ARC/INFO software at university prices is highly commendable. MENRIS has also acquired ERDAS Imaging software for image processing. Besides, MENRIS has the IDRISI and ILWIS software programmes, and these are basically used for training purposes.

During the establishment phase, MENRIS trained its staff in the latest GIS technology and developed training materials. Also, development of pilot GIS case studies has been carried out to demonstrate the applicability of GIS technology.

Training

Many GIS applications have been developed for regions other than the mountains and very few institutions are engaged in GIS training that is focussed on the mountain environment. Because GIS is a relatively new technology in the HKH region, the lack of trained manpower is felt severely. Recognising this fact, the MENRIS programme places training as the highest priority activity. The MENRIS Training Centre is playing an active role in developing and imparting training on GIS with applications associated with the development issues of the mountain environment and its natural resources. Training materials have been developed which are targetted at various audiences: decision-makers, managers, professionals, and technicians. These are being used to conduct training for staff from agencies concerned with mountain development from participating Regional Member Countries (RMCs).

University Level Training

The growing need for trained manpower in GIS can be best served by a university level training programme. Given the fact that GIS is growing as a separate discipline, or science, on-the-job training with a software-oriented approach is not adequate to fulfill the requirements for trained manpower. Owing to the non-availability of GIS infrastructure in the universities, MENRIS is engaged in capacity-building in the universities of the HKH region. A concerted attempt is being made to introduce GIS technology as a part of the university curriculum to fill this gap on a continuous basis.

Networking

A regional mechanism needs to be established to serve as a useful instrument for pooling resources, expertise, and facilities and to work on common problems in the HKH region for the mutual benefit of participating regional member countries through a network of collaborative institutions. It aims at a decentralised approach to regional cooperation in order to provide appropriate technology and applications' development in the HKH region.

The partnership initiative is designed to extend the functional capabilities of national institutions by developing mutually supportive relationships. These relationships initially focussed on training and GIS dissemination activities. Ultimately, MENRIS seeks to develop a robust, productive GIS environment and attain the common goal of an accurate information base which can then be used for natural resource and environmental applications in the region.

Database Development

The success of GIS depends upon the accuracy of the information base. The rapid growth of MENRIS datasets, along with the increasing demand for environmental and natural resources' data, emphasises the need for a coordinated approach to collection and dissemination of digital data in the HKH region. Having established nodal agencies in the RMCs, MENRIS is making an effort to develop a systematic database on a compatible platform for the specific mountain areas in collaboration with the concerned national agencies. Defining common standards for a database on a sub-national/national and regional scale has been the first step towards collection and dissemination.

Scope of Data

Given the vast scope and an inconceivable volume of data, a clear definition is needed concerning the number of factors to be considered for incorporation into a database that would cater to those working for the development of mountain ecosystems. At present, MENRIS is concentrating on the development of GIS for natural resource and environmental applications on various scales.

Scale	Applications
1:1 million	regional-level analysis
1:25,000	country-level analysis
1:50,000/25000	province/district-level analysis
Topography	Settlements, Contours, Roads, Drainage, Land Use, Land Capability, Land Systems
Ecology	Vegetation, Soil, Climate, Biodiversity, Forests
Economic activity	Inputs, Products, Waste, Wealth and Resource Stores
Social Information	Population, Health, Culture

The following are some key issues MENRIS is currently dealing within the process of database establishment.

- Data Standards
- Data Sensitivity
- Data Quality
- Data Dissemination Procedures
- Database Management and Update

Ensuring that the data collected by different institutions, under different programmes and for different purposes, are comparable and compatible will ultimately facilitate the sharing of information in the public domain and provide a sound decision-making process for the development of the mountain region.

ICIMOD

- International Centre for Integrated Mountain Development
- Includes the Mountain Regions of:

  Afghanistan, Bangladesh,
  Bhutan, China,
  India, Myanmar, and
  Nepal, Pakistan.

MENRIS
1990 - 1995

- Mountain Environment and Natural Resources' Information Service

- **Basic Theme**
  Disseminate GIS Technology in the Hindu Kush-Himalayan Region

Objectives

- Awareness through Training/Workshops
- Network: Regional Level Coordination
- Capacity Building
- Clearing House
- Build and Encourage Information Exchange

GIS Technology: An Integrated Approach

- To integrate biophysical data and socioeconomic data
- To monitor the dynamically changing resource base
- To indicate alternative strategies to decision-makers
- To identify viable technological and institutional options for sustainable mountain development

Establishment Phase

- Installation of Hardware/Software
  - In-House Training

- Training
  - Training Manuals, Pilot Case Studies
  - Reviews

- Partnership Initiatives
  - Contact Key Institutions in the RMCs
  - Contact External Institutions

MENRIS Hardware Set-up

- Resource Centre
  - Two IBM RS/6000 Model 530 Units
  - Four IBM X station 120 Units
  - Five Pentium Units
  - Two IBM 3BT Units and Four IBM 43/P Workstations (1996) Units
- Training Centre
  - 5 Pentium Units with A3 size Digitisers
- Data Input Activities
  - Four Pentium Units with A0 size Digitisers
  - A3 size scanner
- Output Capabilities
  - Tektronix A3 size colour printer
  - HP Paintjet XL300 colour printer
  - Two A0 size 8 pen plotters
  - HP Inkjet 755C ('96)

MENRIS Software Resources

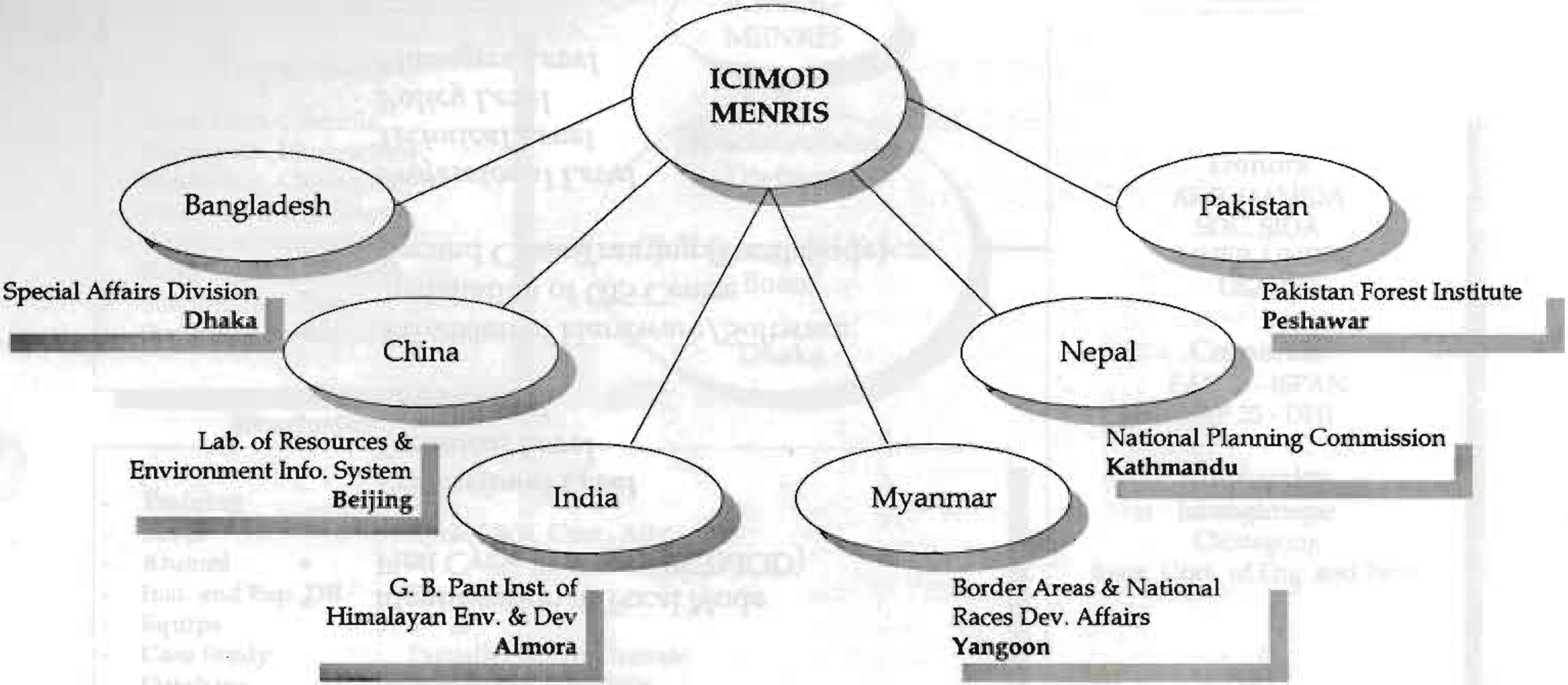
- GIS/RS Software

  - Arc/Info 7.03 Workstation (6 Licenses)
  - Arc/Info 6.1 Workstation (6 Licenses)
  - PC Arc/Info 3.4.2 (12 Copies)
  - Erdas Imagine 8.01 (3 Licenses)
  - PC Erdas Imagine 8.2 (6 copies)
  - PC Erdas 7.5 (1 Copy)
  - ILWIS 1.4 (5 Copies)
  - IDRISI 4.1 (5 Copies)

Implementation Phase

- **Mountain Focus GIS Training Centre**
  - improve training curriculum
  - training for IPC agencies
  - publish training handbooks
- **MENRIS Network Establishment**
  - formalise IPC nodes
  - provide two cycles of training
  - conduct collaborative case studies
  - provide compatible hardware/software
  - provide technical back-up
- **Resource Centre**
  - HKH district database build-up
  - establish focal points for research
  - encourage exchange of information
  - dissemination of studies, research

MENRIS Focal Nodes



MENRIS Node Implementation

- Identification of Focal Node
- First Cycle Training (ICIMOD)

Professional Level
Technical Level
Policy Level

- Provision of Hardware/Software
- Installation of GIS Centre
- Second Cycle Training (Focal Node)

Professional Level
Technical Level
Policy Level
Managers Level

- GIS Case Study Implementation District Based
- Technical Back-Up

MENRIS Network - Bangladesh

Government

Departments

- Local Govt. Councils
  Rangamati, Khagrachari
  Bandarban, Chittagong
- Local Govt. Eng. Dept.
- Bureau of Statistics
- Bang. Agri. Res. Centre
- Soil Res. Dev. Inst.
- Surface Watre Modelling Centre

ICIMOD
MENRIS

Spacial Affairs
Division

Chittagong Hill Tracts
Board

Dhaka

Others

Donors
ADB, DANIDA
SDC, SIDA
UNEP, UNDP
USAID

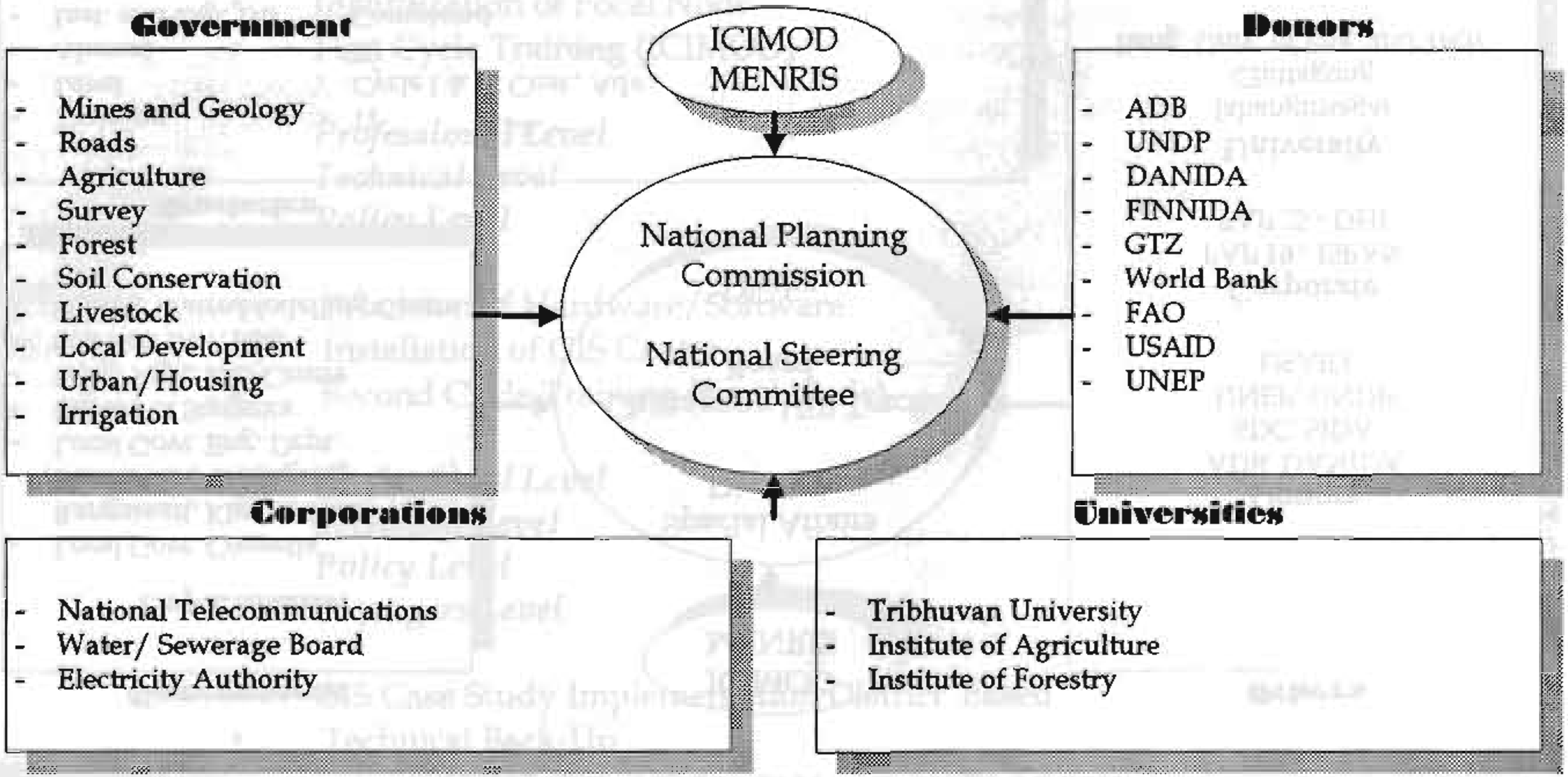
Corporate
FAP 19 - ISPAN
FAP 25 - DHI

University
Jahangirnagar
Chittagong
Bang. Univ. of Eng. and Tech.

Statistics

- **Training**	:	11
- **Level**	:	Cycle I & II, Cust., Adv.
- **Alumni**	:	70
- **Inst. and Exp. DB**	:	Completed
- **Equips**	:	5 + 17
- **Case Study**	:	Partially. Macro - Initiate
- **Database**	:	250k - 1995. 50k - 1996

MENRIS Network for Nepal



Capacity Building - Training

Basic Courses

- **Policy-makers (1 day)**
  - Planners, Decision-makers

- **Professional (4 wks)**
  - Foresters, Engineers
  - Economists, Agriculturists
  - Scientists, Ecologists

- **Technical (4 wks)**
  - Data Managers,
  - Cartographers, Draftsmen

Tailored Courses

- **Managers' Training (1wk)**
  - Project Managers

- **Advanced ARC/INFO (2wks)**
  - Professional, Technical

- **Remote Sensing - ERDAS**
  - Professional (3wks)

- **GPS Training**
  - Technical (1wk)

Case Studies	Collaboration with
• *Melamchi Water Transfer*	*Dept. of Mines*
• *Settlement Mapping Using GIS*	*ODA*
• *Livestock Carrying Capacity*	*GTZ*
• *Service Centre Location*	*UNDP*
• *Lamjung District Info. System*	*GTZ*
• *Planning Agri. Development in Gorkha-Baseline Data*	*GTZ*
• *Climatic Atlas*	*DOMH*

GIS Databases

- **Scale**
  - 1:1 million — regional level
  - 1:250,000 — country level
  - 1:25,000/50,000 — district/provincial level

- **Scope of Data**
  - topography
  - ecology
  - socioeconomic activity

Database Issues

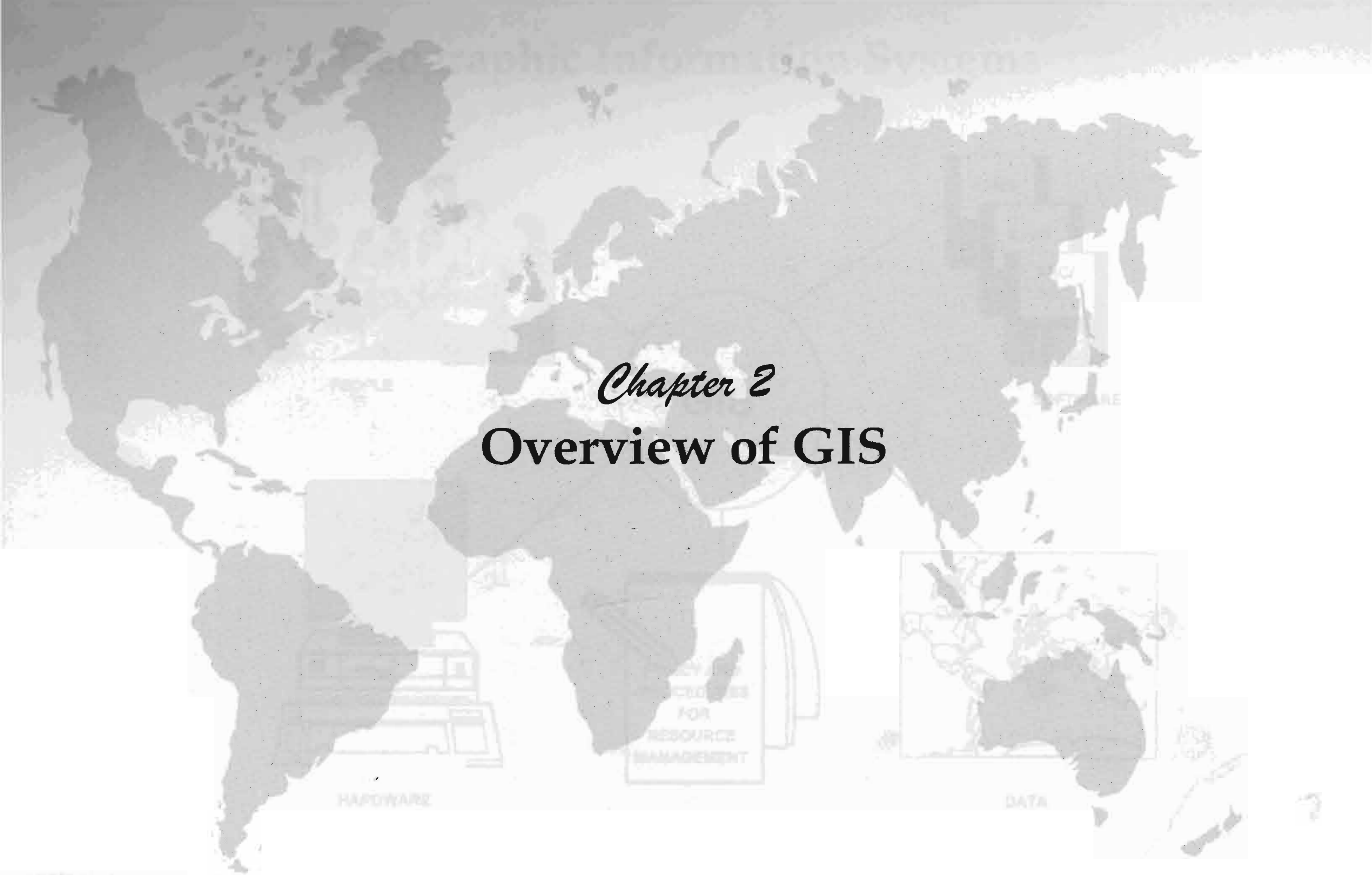
- Data Access
- Data Standardisation
- Data Sensitivity
- Data Quality
- Data Dissemination Procedures
- Database Management and Update

Future Strategies

- Work Closely with National Institutions in the HKH Region in GIS and Remote Sensing Applications
- Build-up Regional Databases on Natural Resources and the Environment
- Advanced Training Centre
- Exploit New Technology Development
- Satellite/Radar/GPS Technology
- Conduct Collaborative Applications
- Consultative Role

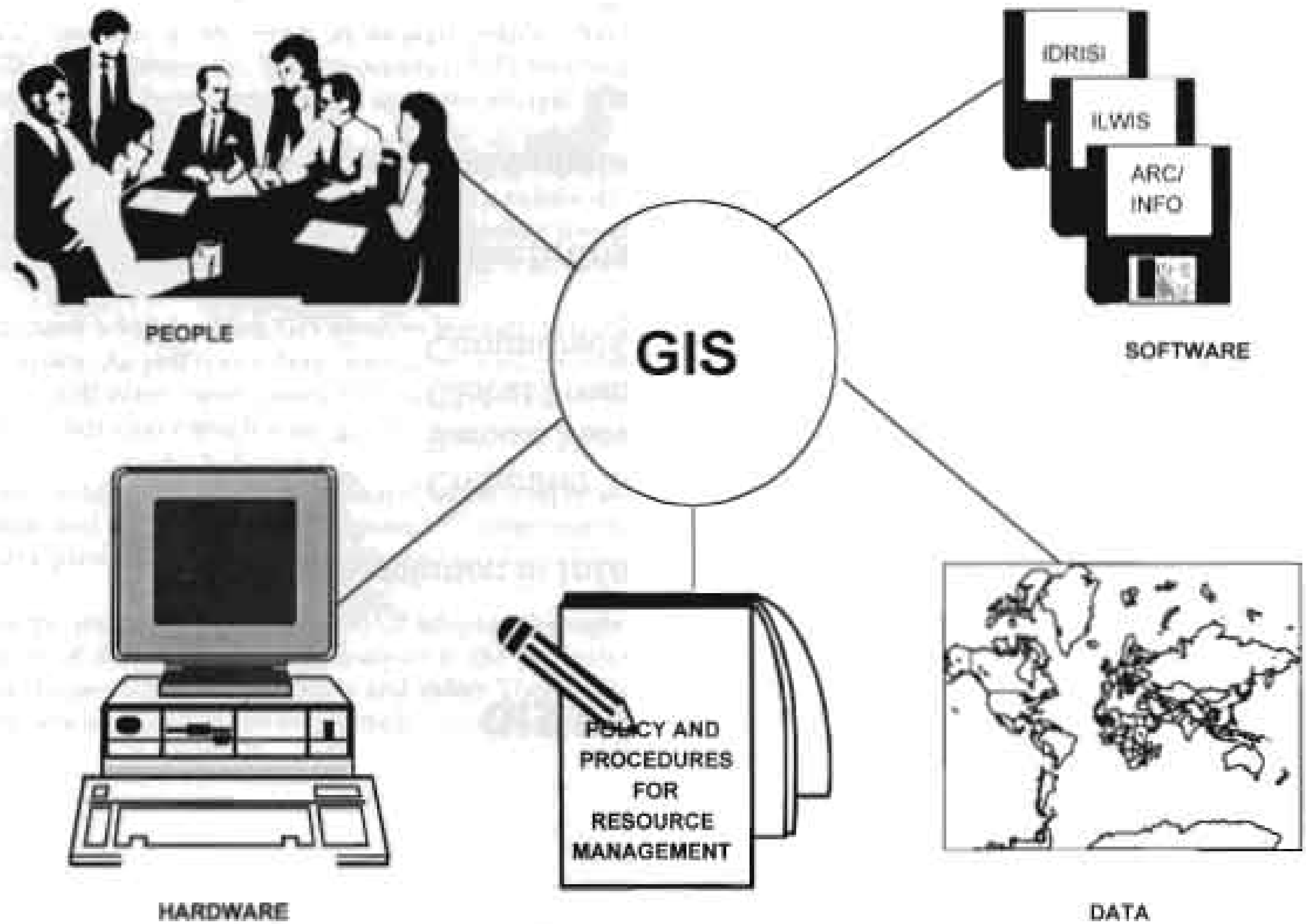
MENRIS Appeal

- Encourage Information Exchange
- Encourage All Work in Digital Form
- Adhere to Compatible Hardware/Software Platforms
- Stress Non-Duplication of Effort



Chapter 2
Overview of GIS

Geographic Information Systems



GIS Evolution

- revolution in **information technology**
  - Computer Technology
  - Remote Sensing
  - Global Positioning System (GPS)
  - Communication Technology
- rapidly **declining cost** of computer hardware
- enhanced **functionality** of software

The Philosophy of GIS

GIS has had an enormous impact on virtually every field that manages and analyses spatially distributed data. For those who are unfamiliar with the technology, it is easy to see it as a magic box. The speed, consistency, and precision with which it operates is truly impressive. Moreover, its strongly graphic character is hard to resist. However, the experienced analyst see the philosophy of GIS quite differently. With experience, GIS becomes simply an extension of one's own analytical thinking. The system has no inherent answers, these depend upon the analyst. It is a tool, just like statistics is a tool. It is a tool for thought.

Investing in GIS requires more than an investment in hardware and software. Indeed, in many instances this is the least of concerns. Most would also recognise that a substantial investment needs to be made in the development of the database. However, one of the least recognised and most important investments is in the analysts who will use the system. The system and the analyst cannot be separated – to put it simply, one is an extension of the other.

In many ways, learning GIS involves learning to think – learning to think about patterns, about space, and about processes that act in space. As you learn about specific procedures, they will often be encountered in the context of specific examples. In addition, they will often have names that suggest their typical application. But resist the temptation to categorise these routines. Most procedures have much more general applications and can be used in many novel and innovative ways (Idrisi Student Manual).

The proliferation of GIS is explained by its unique ability to assimilate data from widely divergent sources, to analyse trends over time, and to spatially evaluate potential environmental impacts caused by development. Such advances in information technology have provided governments with the means to address the requirements of spatial data management in developing countries.

As the technology becomes widely adopted throughout the world, there are signs that its functions are gradually changing from those of data collection and analysis to the promotion of visualisation, incorporating a variety of existing data sources and new techniques such as multimedia and video. These techniques will ensure that the data, and in particular geo-reference information, become more accessible to non-technical audiences.

Why GIS?

- 70% of the information includes some geographical facts in the decision-making process
- Ability to assimilate divergent sources of data both spatial and non-spatial (attribute data)
- Visualisation impact
- Sharing of information
- Analytical capability in a spatial context

Why GIS ?

Many professionals, such as foresters, urban planners, and geologists, have recognised the importance of spatial dimensions in organising and analysing information. Whether a discipline is concerned with the very practical aspects of business, or whether a discipline is concerned with purely academic research, geographic information systems can introduce a perspective which can provide valuable insights.

GIS are a means to an end, not an end in themselves. The value of GIS lies not just in the immediate efficiency with which the technology is implemented. Rather, it lies in how the technology helps us to think differently about the way we organise, understand, and use spatial information. New appreciation of the importance of spatial location or geography in real world analysis has emerged from the application of GIS technology. Predictions suggest that billions of dollars will be spent on GIS technology and its applications. The basic factors affecting the diffusion of GIS are due to reasons described below.

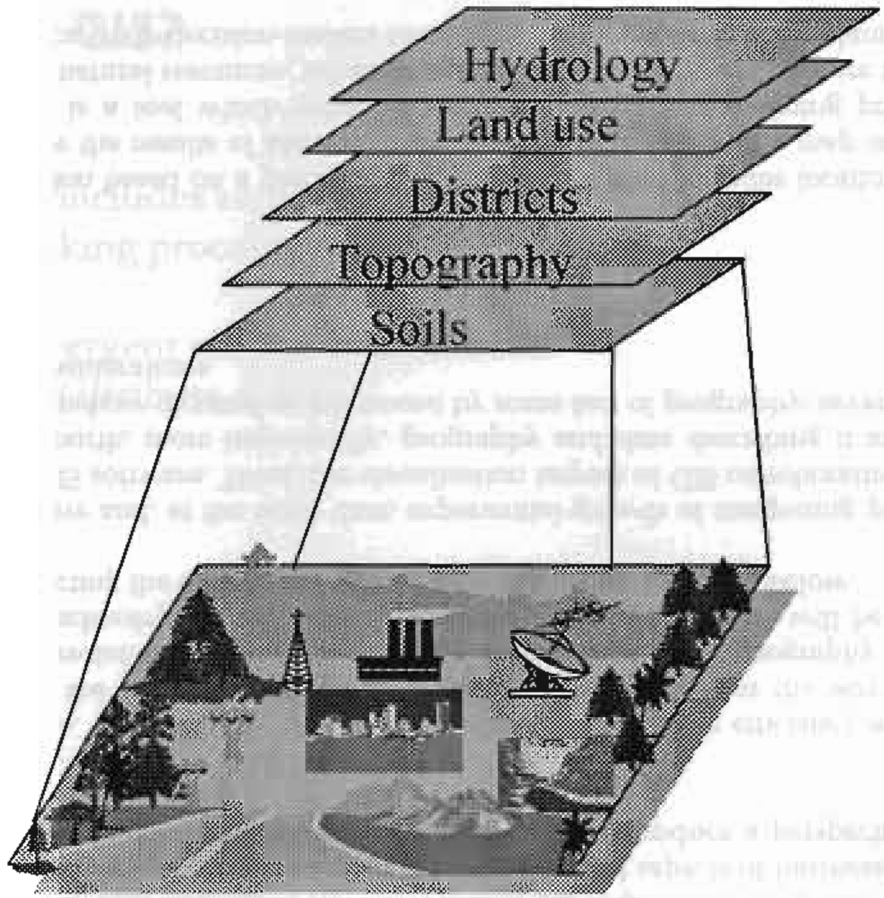
First, the rapidly declining cost of computer hardware and, at the same time, exponential growth of computing power. Second, user-friendly software and increasing functions of GIS software. Third, the visualisation impact of GIS corroborating the Chinese proverb "a picture is worth a thousand words." Fourth, more importantly, geography and data describing it are part of our everyday lives; almost every decision we make is somehow dictated or influenced by some fact of geography; seventy per cent of the decisions, we make are based on geographical considerations.

Thinking Spatially

Thinking spatially is a method of assessing a situation based on a perception of information that includes location. Part of this method would typically include the ability to review the results of assessment or analysis in the form of a map or some sort of report which identifies a geographic location. GIS is a tool which enhances decision-making and planning processes. Most planning applications, be they environmental or for natural resources, urban or agricultural development, require this approach. The three-dimensional spatial analysis ability of GIS can help decision-makers to address the mountain-specific planning processes in a more realistic way.

GIS

A computer-based system, capable of holding and using data describing places on the earth's surface.



The real world consists of many geographies which can be represented as a number of related data layers.

GIS Definition

Geographic data have traditionally been presented in the form of a map. Large-scale development of computer hardware and software is increasing the use of maps dramatically. Many organisations now spend a large amount of money on Geographic Information Systems (GIS) and on geographic databases. The costs of computer hardware and software are decreasing rapidly, and programmes are becoming more user-friendly, making GIS accessible to a large number of people.

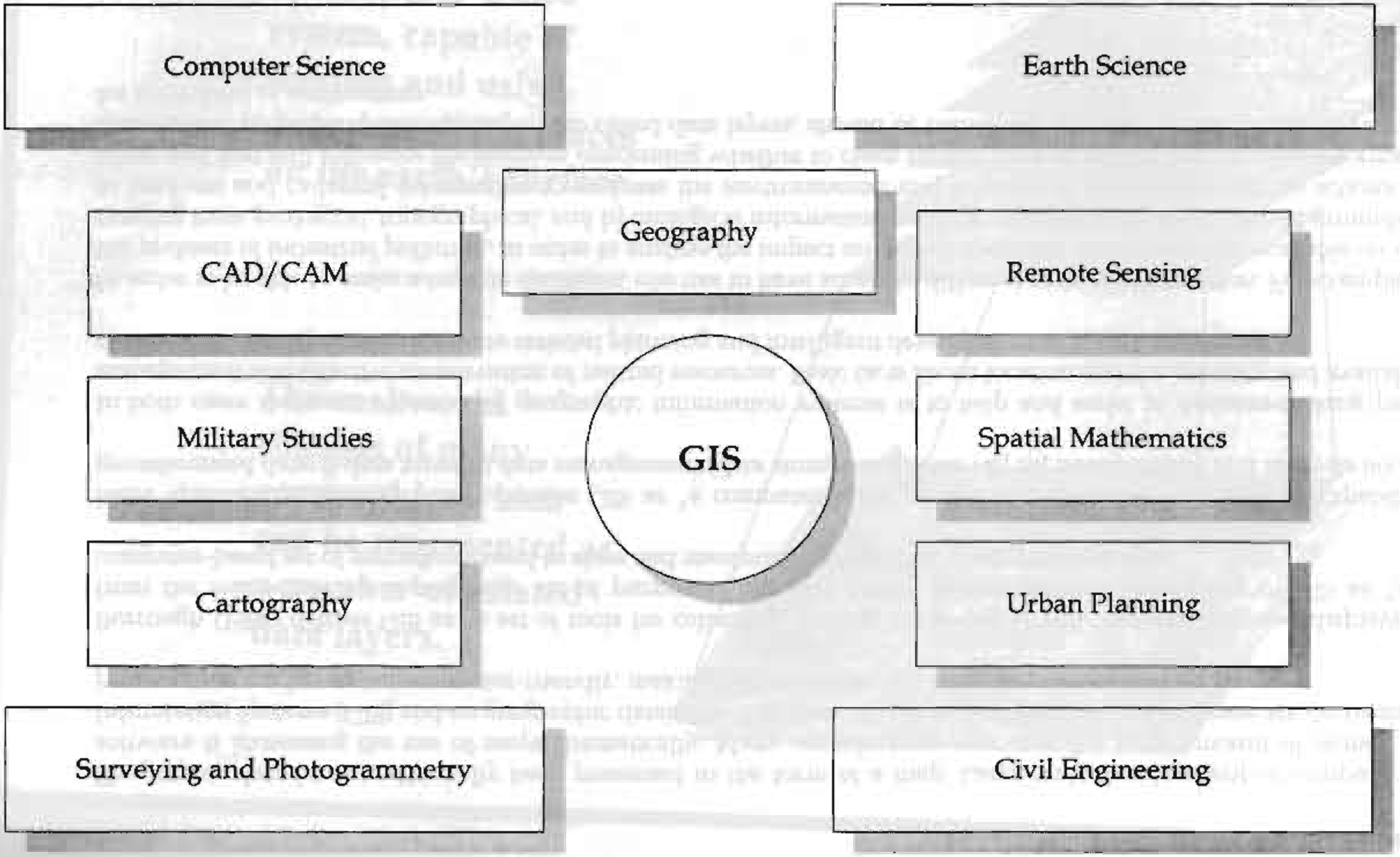
Burrough (1986) defines GIS as "a set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes." Aronoff (1989) gives a general description of GIS as "any manual or computer-based set of procedures used to store and manipulate geographically-referenced data."

More specifically, Aronoff (1989) defines GIS as "a computer-based system that provides four sets of capabilities to handle georeferenced data: i) data input ii) data management (data storage and retrieval) iii) manipulation and analysis iv) data output."

In both cases the main objective of geographic information systems is to help and assist in decision-making processes for the management and effective conservation of natural resources. Basic facts about location and the quantity and availability of natural resources are indispensable for more rational planning and intelligent development of natural resources.

In order to be able to make adequate decisions, one has to have access to different sorts of information. For example, in the case of the problem of industrial pollution, in order to analyse the impact on the environment, data should be available on various aspects, ranging from geological, topographical, and hydrological information used for modelling the dispersion of groundwater pollution to land-use and cadastral information to evaluate the environmental and economical implications of the actions that should be taken and that will influence the decision concerning whether to clean up the mess or not. In this process, information of various dimensions, present in different maps, also called data layers, should be combined. In other words, GIS are a very important tool for these kind of applications.

GIS Historical Development



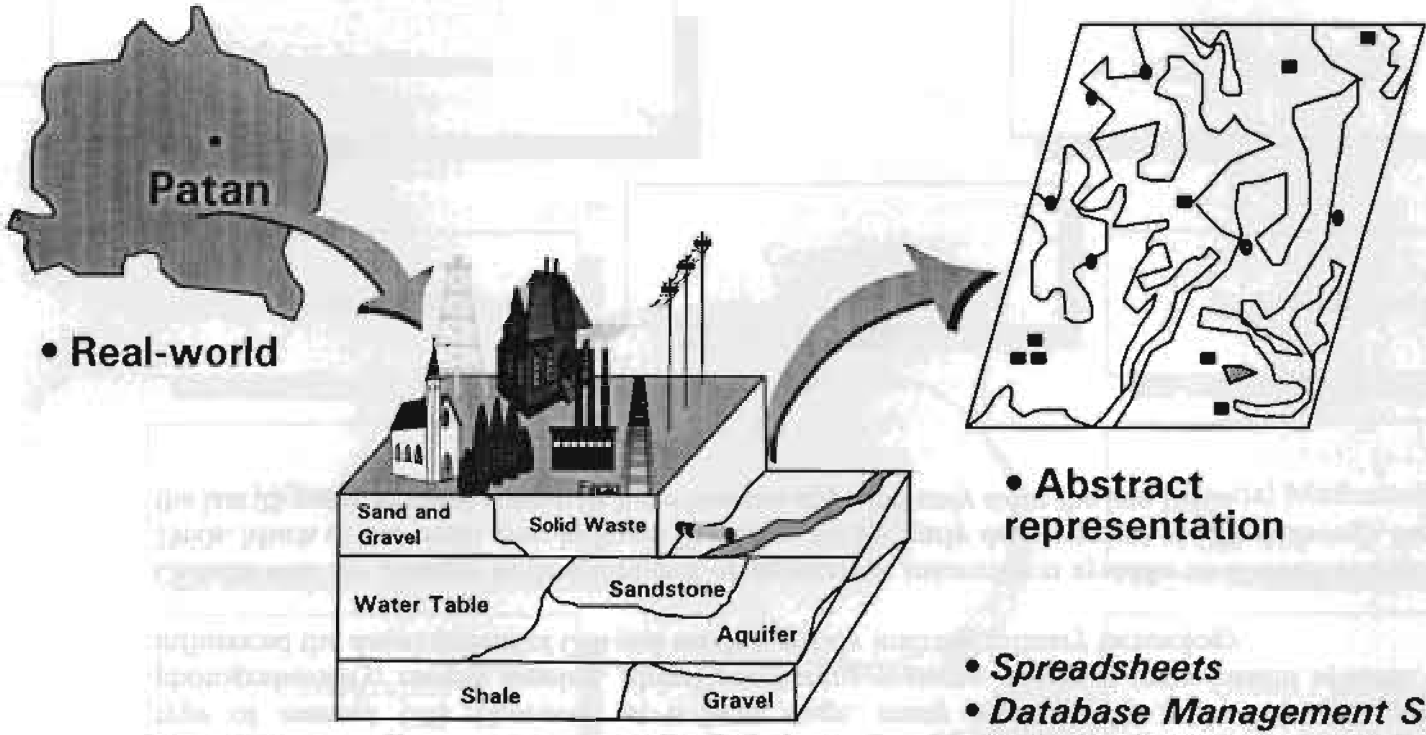
History of GIS

GIS, and the beginnings of simple spatial analysis, would not exist without geography and cartography. The contributions made by information and systems' development, in conjunction with the advancement in computer technology, have made GIS a powerful analytical tool.

The GIS technology has evolved from geography and geo-type disciplines. Cartographic map production can be taken as the first type of manual GIS. However, at a later stage, many other fields, such as civil engineering, computer cartography, photogrammetry, remote sensing, global positioning systems, database management systems, earth sciences, and so on have influenced the development of GIS and made it a truly interdisciplinary technology.

Canada was the pioneer in development of geographic information systems as a result of innovations dating back to the early 1960s. Much of the credit goes to Roger Tomilson for the early development of GIS. Although the field of GIS has been around for the last 25 years, the real potentials have become apparent only since the late 1980s.

Handling Geographic Information



- *Spreadsheets*
- *Database Management Systems (DBMS)*
- *Computer Aided Design (CAD)*
- *Cartographic Packages*
- *Photogrammetrical Software*
- *Image Processing Software*

Spatial Operations

Many computer programmes can handle geographic data such as those described below.

Spreadsheets (e.g., Lotus 1-2-3, QuatroPro). A spreadsheet can be thought of as a large imaginary piece of electronic paper that can contain information in rows and columns, which is used for all sorts of (mathematical) operations for producing graphs. Spreadsheets are often used in combination with GIS.

Database Management Systems (e.g., Oracle, dBase). A Database Management System (DBMS) is a set of programmes which is a collection of information about things and their relationships to each other and which maintain and manipulate data in a database. A DBMS only handles "attribute data" and cannot handle maps. It generally forms an integrated part of GIS.

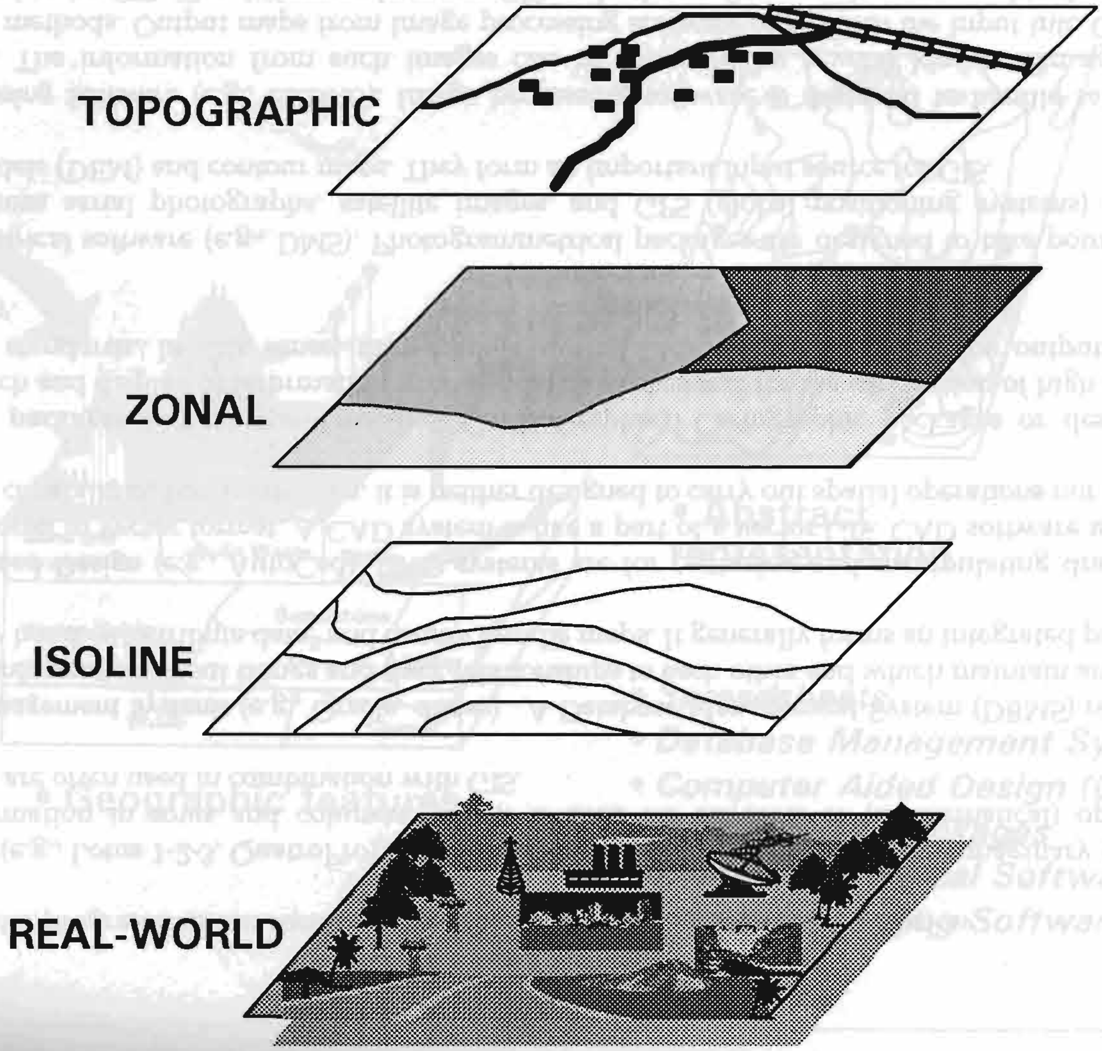
Computer Aided Design (e.g., AutoCad). CAD systems are for capturing and manipulating drawings. Point, line, and polygon objects are stored in vector format. A CAD system is like a part of a vector GIS. CAD software is highly developed and has very good display capabilities, but, on its own, it is neither designed to carry out spatial operations nor use raster data types.

Cartographic packages (e.g., Aldus Freehand, CarthoGraphix). Cartographic packages or desktop mapping systems are for selective search and display of information from spatial databases and for the production of high quality output maps which meet cartographic standards. In this sense, they form a useful addition to GIS, since the output facilities of most GIS are still unsatisfactory.

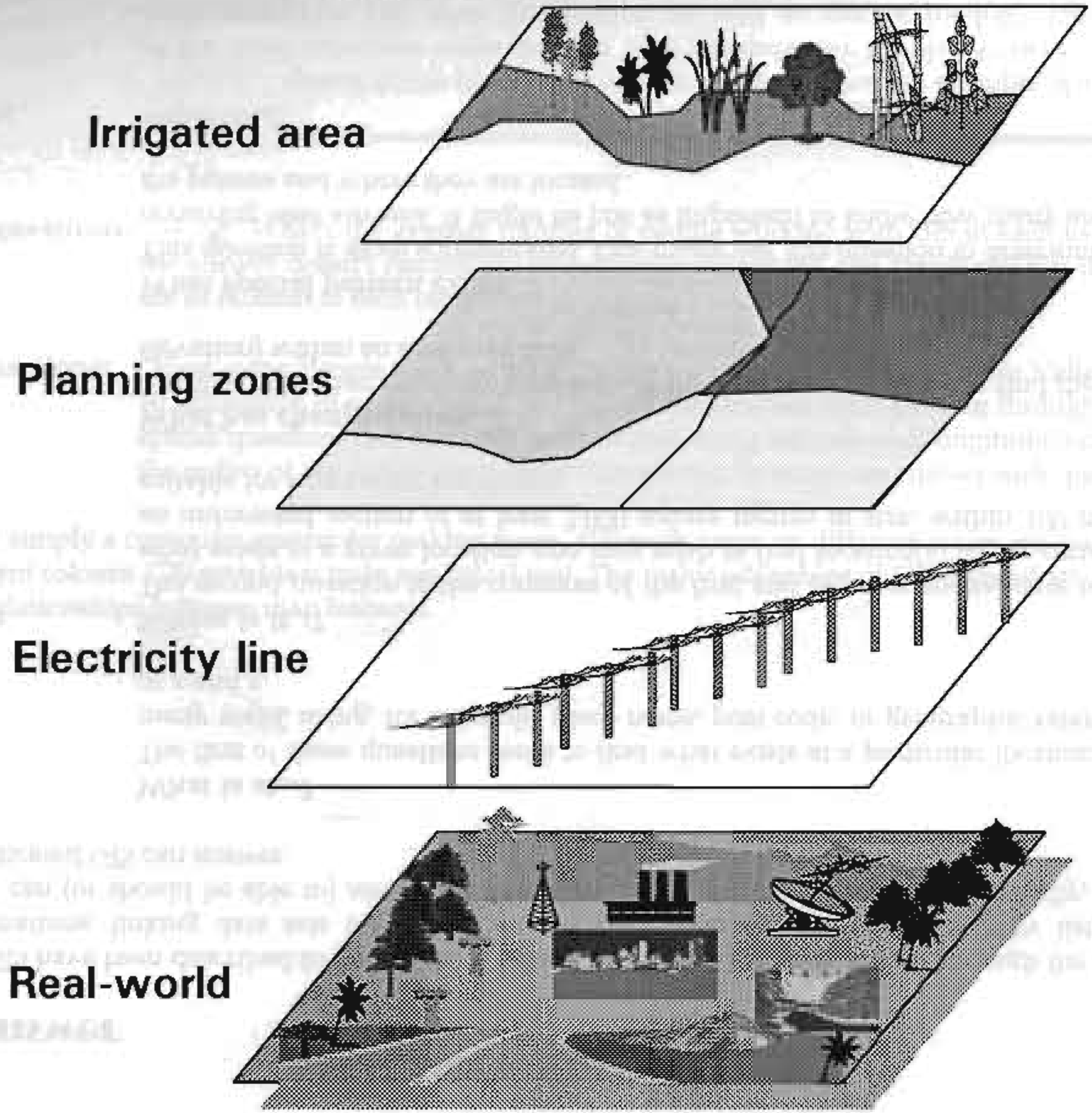
Photogrammetrical software (e.g., DMS). Photogrammetrical packages are designed to take point sample data (mostly of terrain elevations) from aerial photographs, satellite images, and GPS (global positioning systems) data, and then produce digital elevation models (DEM) and contour maps. They form an important input source for GIS.

Image Processing Software (e.g., ERDAS). Image processing software is designed to handle satellite images, or scanned aerial photographs. The information from such images can be extracted by several kinds of image enhancement techniques and classification methods. Output maps from image processing software often form the input into GIS. These software packages are not considered to be GIS. The difference between GIS and other software using geographic data is that only GIS permit spatial operations on the data.

Maps and Spatial data



What can GIS do?



Questions GIS can answer

Thus far, GIS have been described in two ways: i) through formal definitions, and ii) through the technology's ability to carry out spatial operations, linking data sets together. One can also, however, distinguish GIS by listing the types of questions the technology can (or should be able to) answer. If one considers a particular application carefully, there are five types of question that sophisticated GIS can answer.

Location

What is at...?
The first of these questions seeks to find what exists at a particular location. A location can be described in many ways, using, for example, place name, post code, or geographic reference such as longitude/latitude or x and y.

Condition

Where is it...?
The second question is the converse of the first and requires spatial data to answer. Instead of identifying what exists at a given location, one may wish to find location(s) where certain conditions are satisfied (e.g., an unforested section of at least 2,000 square metres in size, within 100 metres of a road, and with soils suitable for supporting buildings).

Trends

What has changed since...?
The third question might involve both of the first two and seeks to find the differences (e.g., in land use or elevation) within an area over time.

Patterns

What spatial pattern exists...?
This question is more sophisticated. One might ask this question to determine whether landslides are mostly occurring near streams. It might be just as important to know how many anomalies there are that do not fit the pattern and where they are located.

Modelling

What if...?
"What if.." questions are posed to determine what happens, for example, if a new road is added to a network or if a toxic substance seeps into the local groundwater supply. Answering this type of question requires both geographic and other information (as well as specific models). GIS permits spatial operation. For example:

Name	Latitude	Longitude	Population
Kathmandu	27°42′ N	85°20′ E	421258
Lalitpur	27°41′ N	85°18′ E	115865
Bhaktapur	27°40′ N	85°26′ E	61405

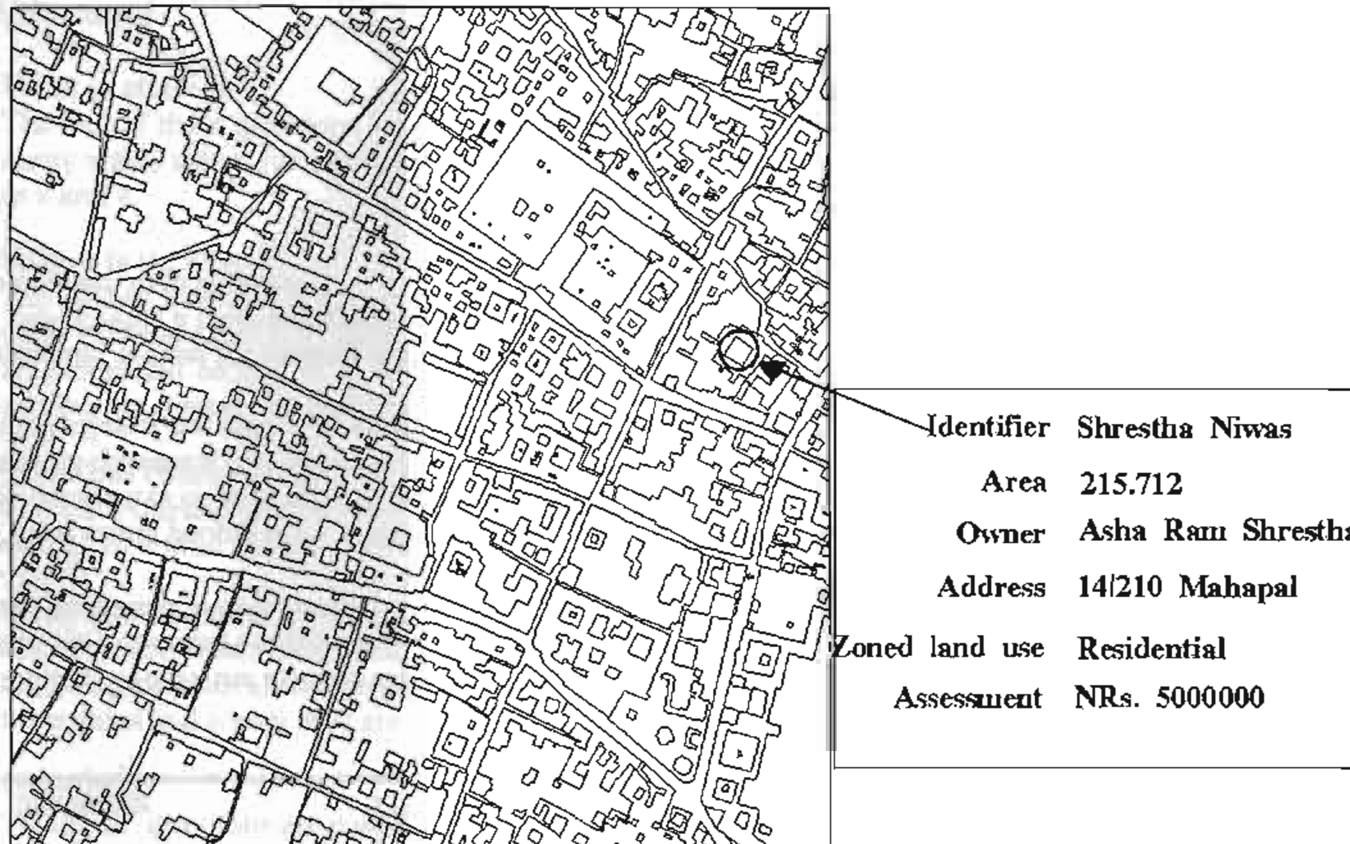
Aspatial questions: Asking "What's the average number of people working with GIS in each location?" is an aspatial question - the answer doesn't require the stored value of latitude and longitude; nor does it describe where the places are in relation to each other.

Spatial questions: "How many people work with GIS in the major centres of Kathmandu Valley", or "Which centres lie within 10 kilometres of each other?", or "What's the shortest route passing through all of these centres?" These are spatial questions that can only be answered using latitude and longitude data and other information such as the radius of the earth. Geographic Information Systems can answer such questions.

GIS are not simply a computer system for making maps, although maps on different scales are created in different projections and with different colours. GIS provide a truly analytical tool. The major advantage of GIS technology is that it facilitates identification of spatial relationships between map features.

GIS Questions - Locations - What is at ... ?

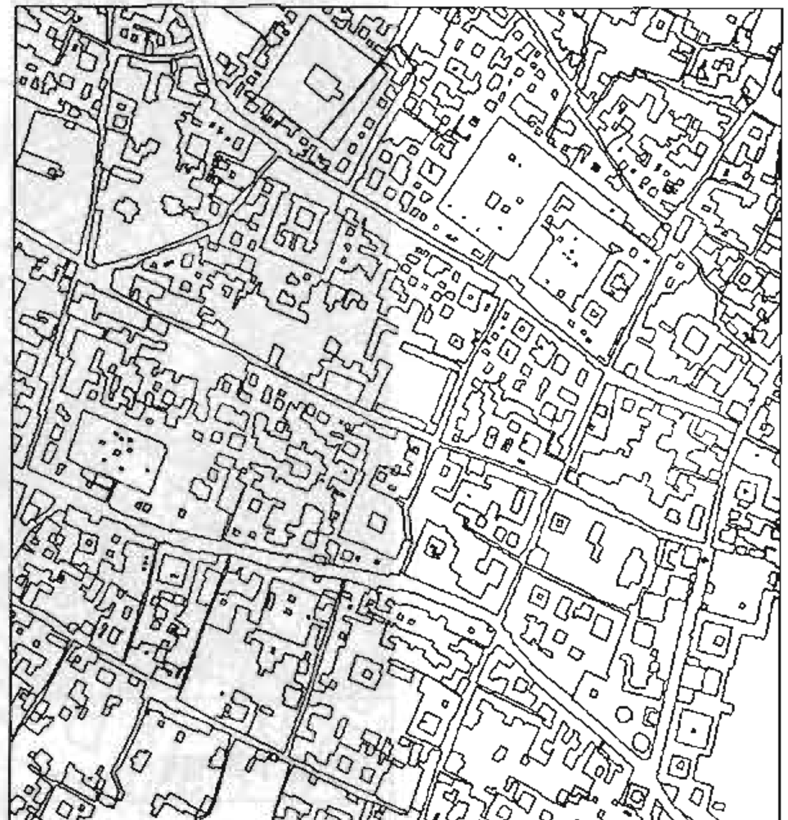
Mangal Bazar, Lalitpur District



Who owns the land at Mangal Bazar, and what is an assessment?

GIS Questions - Conditions - Where is it ... ?

Mangal Bazar, Lalitpur District

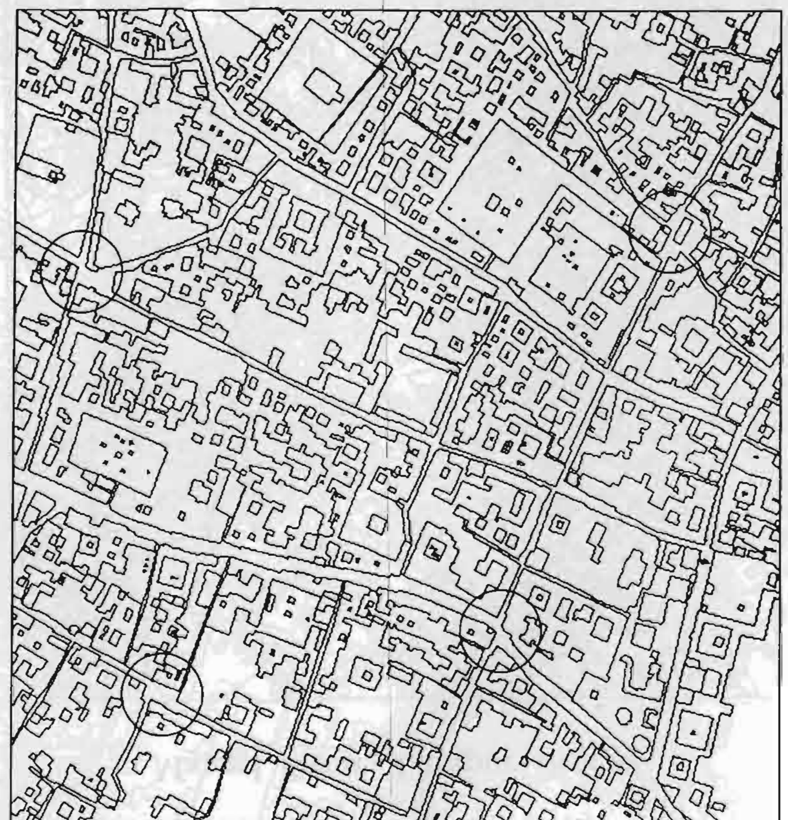


Residential Land use
Assessed at less than Rs. 500000
4 bedrooms
Made of local bricks

Where are houses that you might consider buying located?

GIS Questions - Patterns - What data are related ... ?

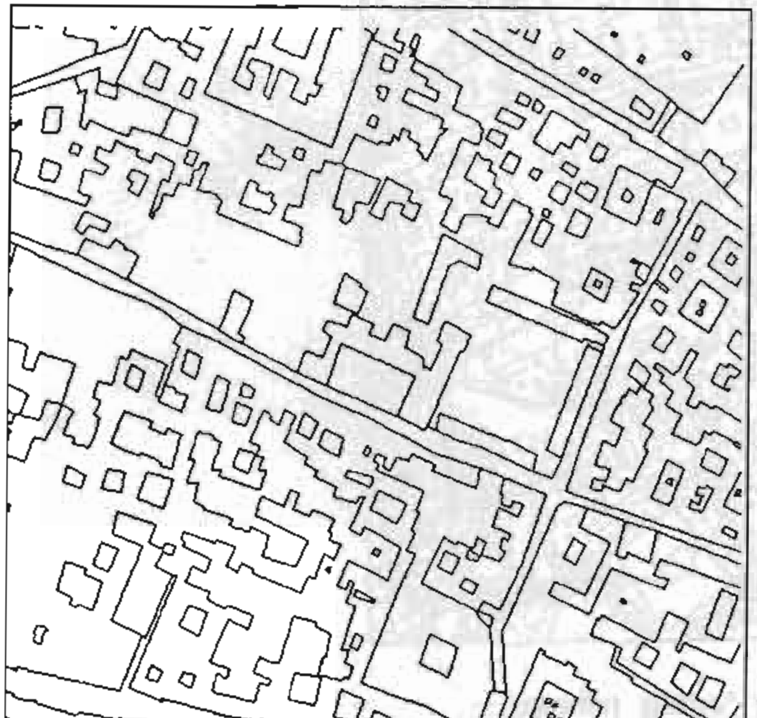
Mangal Bazar, Lalitpur District



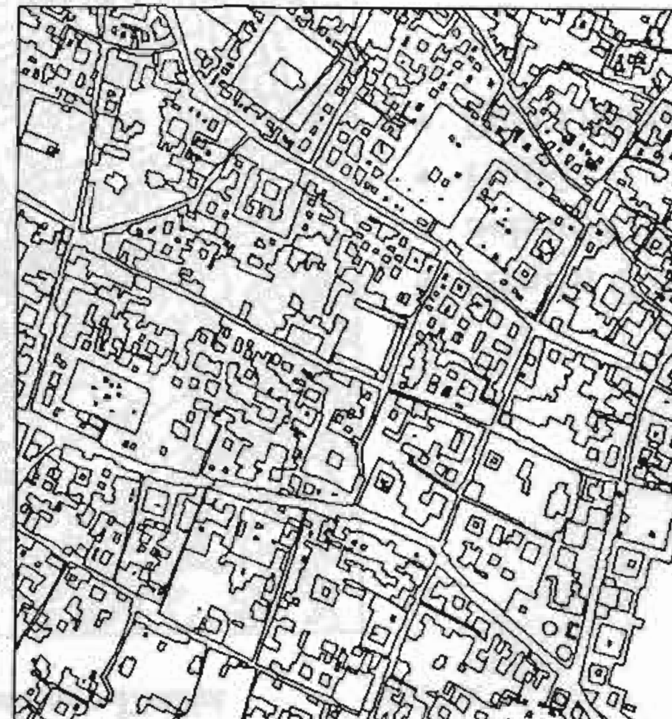
What kind of patterns exist that provide potentials for vehicular accidents?

GIS Questions - Trends - What has changed since ... ?

Mangal Bazar, Lalitpur District



1970

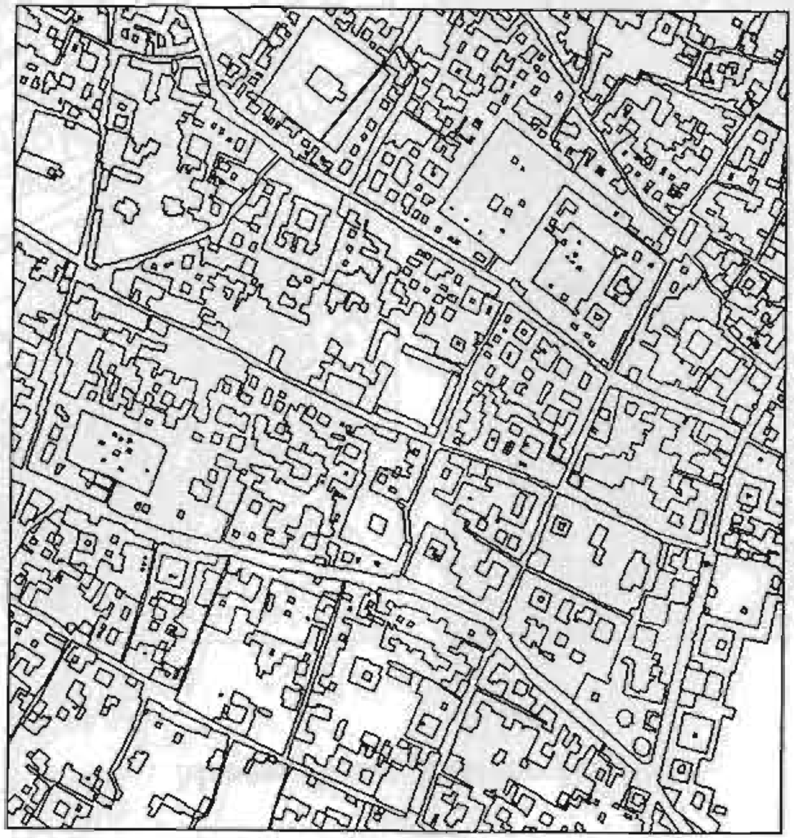


1990

How much land has been used for residential construction since 1970?

GIS Questions - Models - What if ... ?

Mangal Bazar, Lalitpur District



- Health Centre?
- School?
- Hotel?
- Post Office?

Where would you want to open a new service centre?

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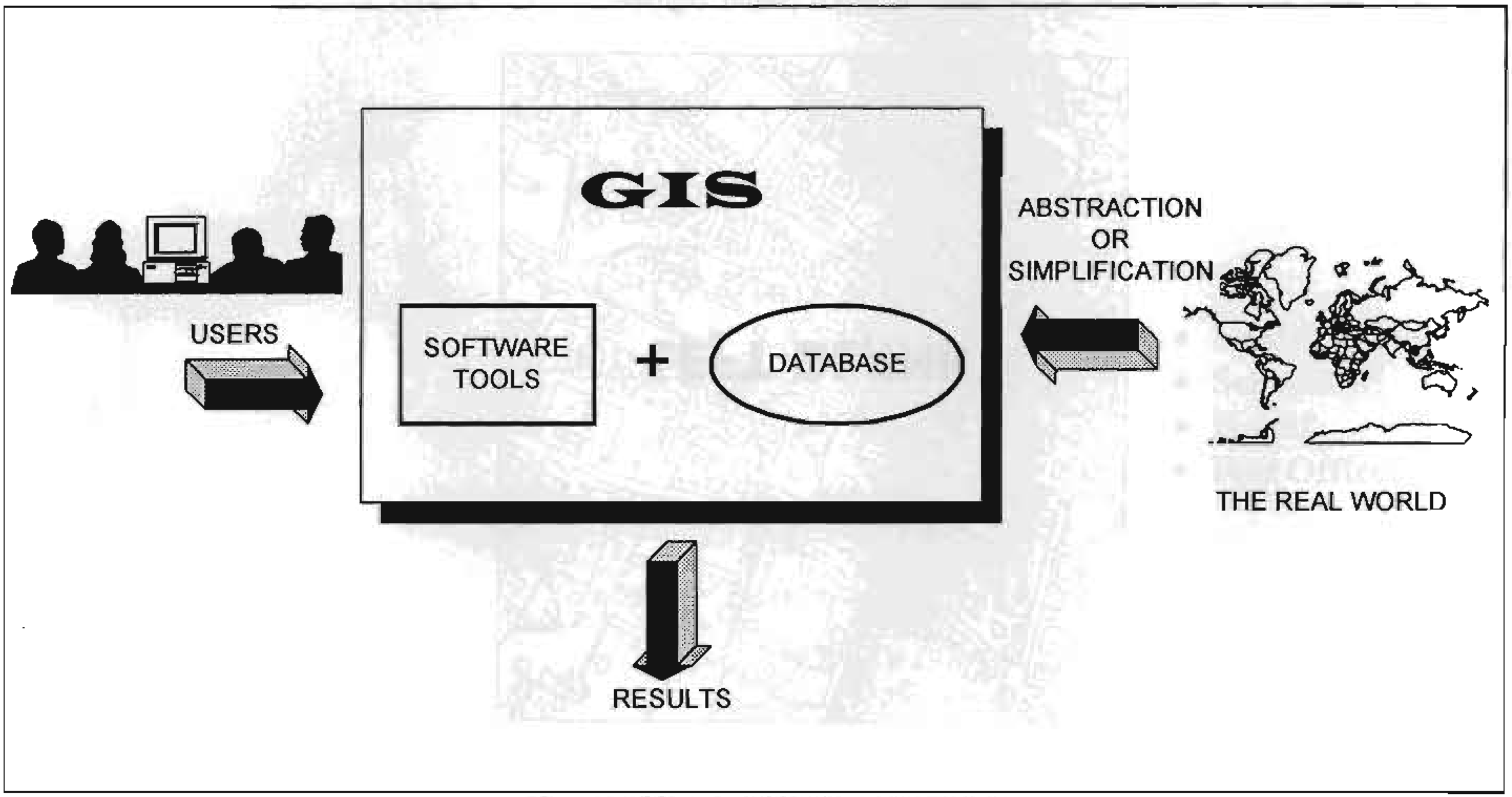
Components of GIS



Components of GIS

Several components are involved in GIS technology.

Hardware

A computer and the associated peripherals are essential for handling spatial data in GIS. These devices are collectively known as hardware.

Software

Software refers to the programmes that run on computers; these include programmes to manage the computer and to perform specific functions. For example, Lotus, dBase, WordPerfect, and ARC/INFO are specialised software programmes designed to perform certain tasks.

Database

A central theme to GIS is the database. A GIS database deals with spatial data. GIS facilitate integration of spatial and attribute data and this makes GIS unique in contrast to other database systems. The beauty of GIS technology lies in the ability to assimilate disparate sources of data and analyse them.

Human Input

People who work with GIS form the most important component. GIS constitute truly a interdisciplinary field and require varied backgrounds of expertise, depending upon the applications. In addition, for technical management, a Hardware Specialist, System Administrator, and Database Manager are required for a corporate GIS set-up.

Policy and Procedures

A methodology is a must to derive the results users need. Basically, this includes spatial analysis for the particular appli-cation. By and large, this depends upon the institutional framework and its interest in exploiting GIS technology for decision-making.

Applications of GIS

- Natural Resources' Applications
- Environmental Applications
- Socioeconomic Applications
- Management Applications

GIS Applications

Computerised mapping and spatial analysis have been developed simultaneously in several related fields. The present status would not have been achieved without close interaction between various fields such as utility networks, cadastral mapping, topographic mapping, thematic cartography, surveying and photogrammetry remote sensing, image processing, computer science, rural and urban planning, earth science, and geography.

The GIS technology is rapidly becoming a standard tool for management of natural resources. The effective use of large spatial data volumes is dependent upon the existence of an efficient geographic handling and processing system to transform this data into usable information.

The GIS technology is used to assist decision-makers by indicating various alternatives in development and conservation planning and by modelling the potential outcomes of a series of scenarios. It should be noted that any task begins and ends with the real world. Data are collected about the real world. Of necessity, the product is an abstraction; it is not possible (and not desired) to handle every last detail. After the data are analysed, information is compiled for decision-makers. Based on this information, actions are taken and plans implemented in the real world.

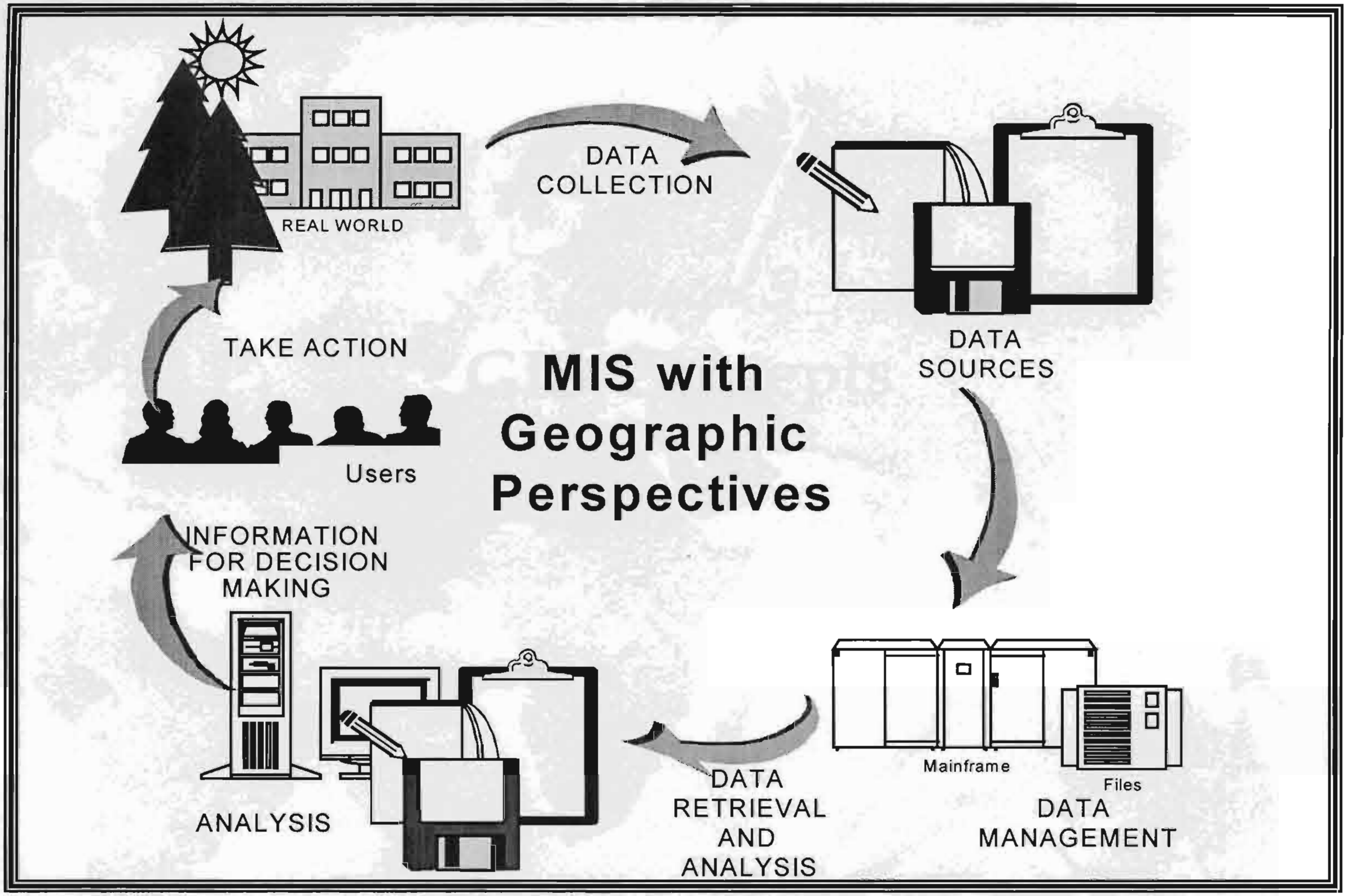
Some typical examples of GIS applications within natural resource planning are:

- land-use planning and management
- mineral exploration
- environmental impact studies
- management of natural resources
- management of water resources
- natural hazard mapping
- forestry and wildlife management
- soil degradation studies
- monitoring desertification
- agricultural development

Sample GIS Applications

- Land-use planning and management
- Mineral exploration
- Environmental impact studies
- Management of natural resources
- Natural Hazard Mapping
- Forestry and wildlife management
- Soil degradation studies
- Monitoring desertification

The Planning Process



- Land use planning and management
- Mineral exploration
- Environ[illegible]
- Management of natural resources
- Natural Hazard Mapping
- Forestry and wildlife management
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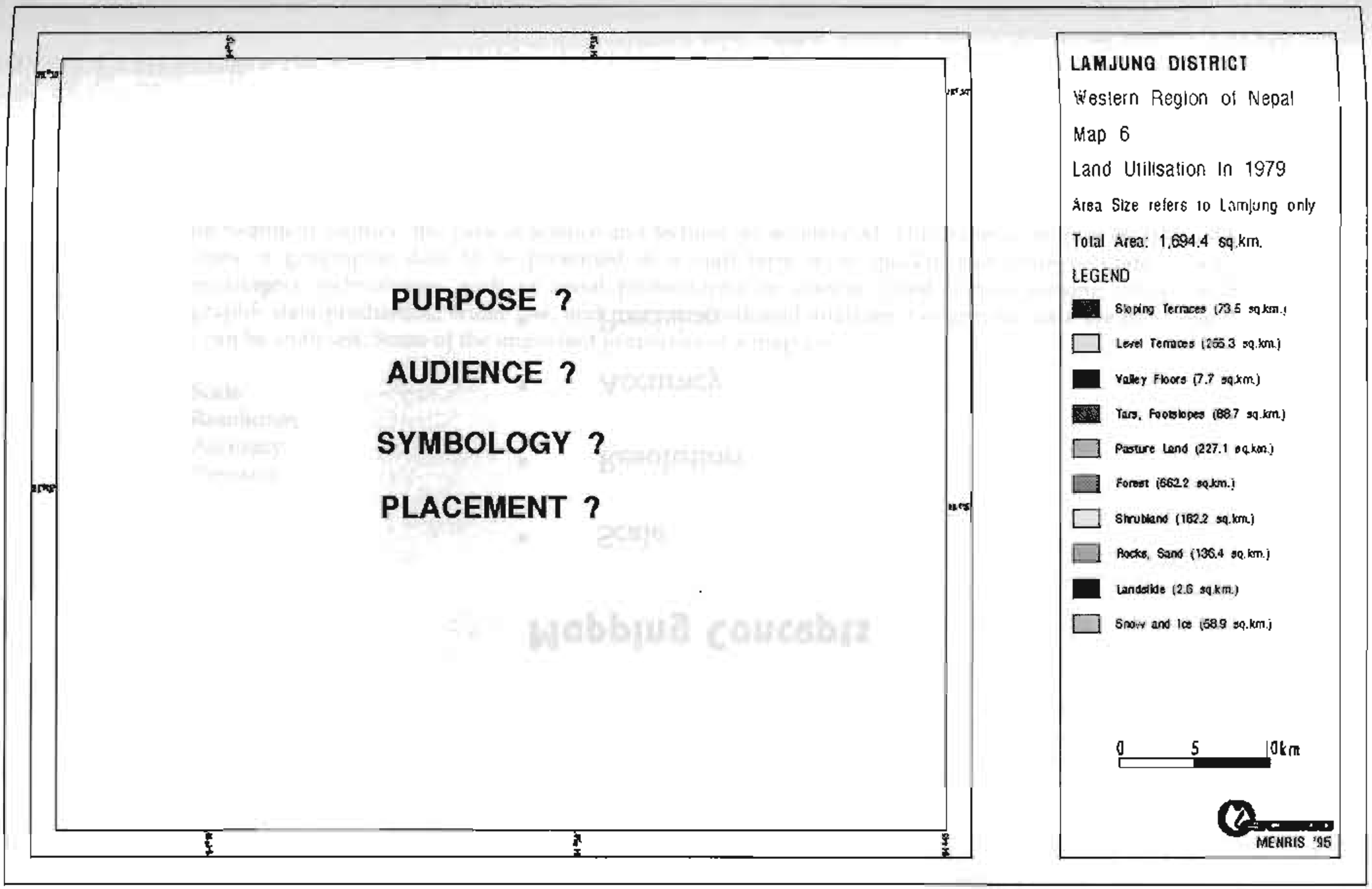
- Monitoring desertification

Chapter 3

GIS Concepts


PURPOSE ?
AUDIENCE ?
SYMBOLOGY ?
PLACEMENT ?
LAMJUNG DISTRICT
Western Region of Nepal
Map 6
Land Utilisation In 1979
Area Size refers to Lamjung only
Total Area: 1,694.4 sq.km.
LEGEND
Sloping Terraces (73.5 sq.km.)
Level Terraces (265.3 sq.km.)
Valley Floors (7.7 sq.km.)
Tars, Footslopes (88.7 sq.km.)
Pasture Land (227.1 sq.km.)
Forest (662.2 sq.km.)
Shrubland (182.2 sq.km.)
Rocks, Sand (136.4 sq.km.)
Landslide (2.6 sq.km.)
Snow and Ice (58.9 sq.km.)
0 5 10km
MENRIS '95

Mapping Concepts

- Scale
- Resolution
- Accuracy
- Precision

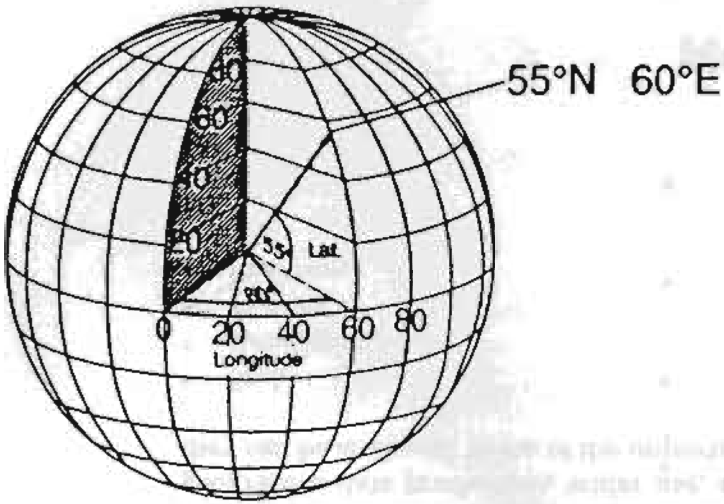
Mapping Concepts

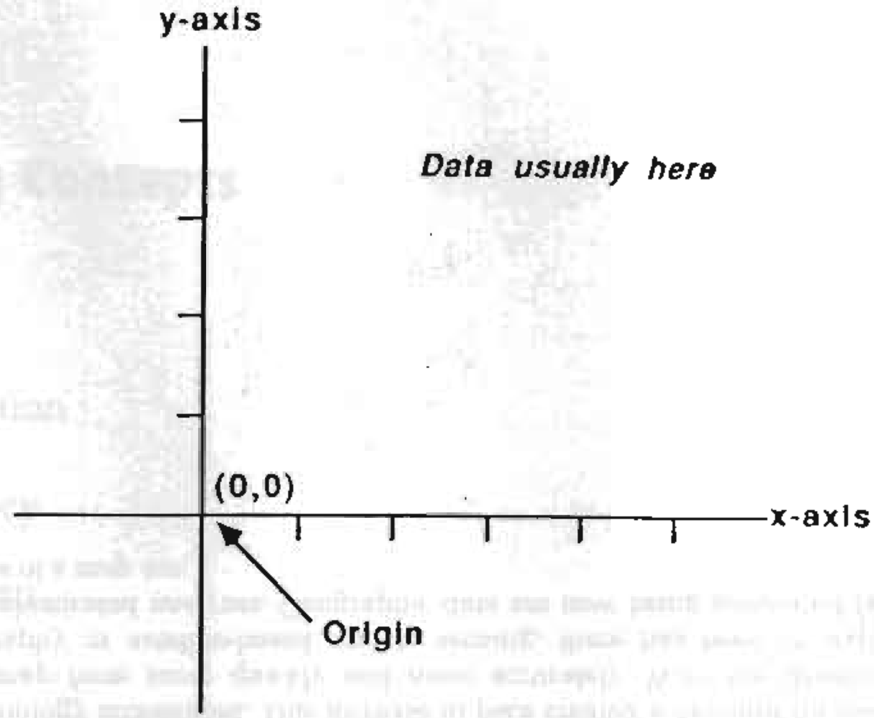
Maps have been used since the earliest times to portray information about the earth's surface. A map is also an information system, normally representing on a certain scale and on a flat medium a selection of material or abstract features on, or in relation to, the surface of the earth.

In the twentieth century, the pace of science and technology accelerated. This increase in pace created a demand for ever greater volumes of geographic data to be presented in a map form more quickly and more accurately. With the development of reconnaissance technologies, such as aerial photography or satellite-based remote sensing, there has been an explosion of geographic data production, wider use, and more sophisticated analyses. Geographic data are now being generated faster than they can be analysed. Some of the important properties of a map are:

- Scale
- Resolution
- Accuracy
- Precision

Coordinate System





- Spherical coordinate system
- Cartesian coordinate system

Projection System

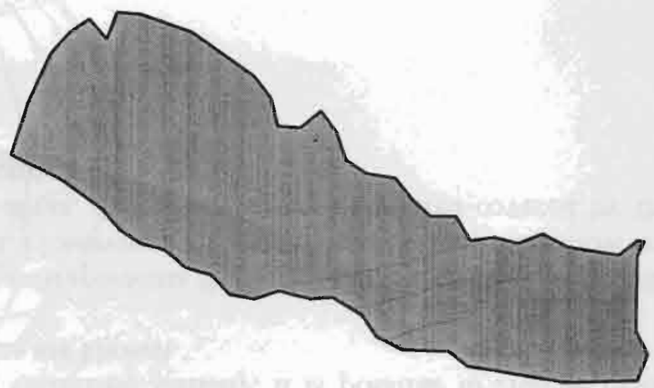
The important globally used coordinate systems are:

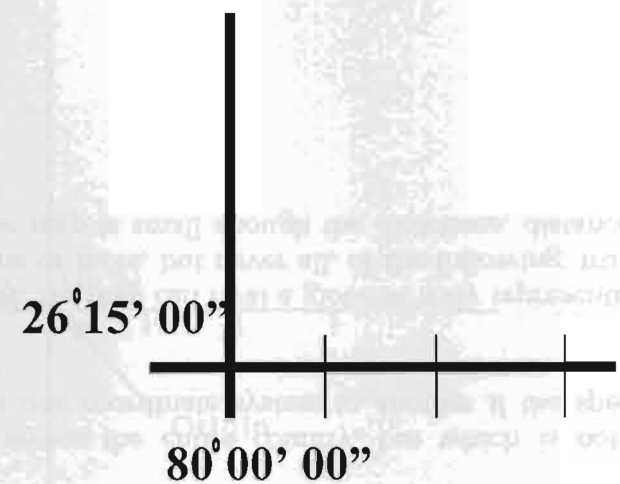
- geographic coordinates (latitude, longitude), (degree, minute, second: DMS),
- UTM (Universal Transverse Mercator) co-ordinates (X,Y) (metres), and
- Lambert Conformal Conic (metres)

Very often a country has its own coordinate system which serves the entire country, but which is not valid for other (neighbouring) countries. Usually, it is possible to change from one coordinate system to another if the specifications of the different systems are known.

Every flat map misrepresents the surface of the earth in some way. No map can rival a globe in truly representing the surface of the entire earth. However, a map or parts of a map can show one or more, but never all, of the following: true directions, true distances, true areas, and true shapes. If the area covered by the map is small enough the directions, distances, and areas are reasonably accurate.

Locating Nepal in Real-World Coordinates





- Global locations
- State Plane Coordinate System
- Latitude & Longitude

The Geographic Coordinate system is a spherical coordinate system composed of parallels of latitude and meridians of longitude. Both divide the circumference of the earth into 360 degrees which are further subdivided into minutes and seconds. Unlike the equator in the latitude system, there is no natural zero meridian. In 1884, it was finally agreed that the meridian of the Royal Observatory in Greenwich, U.K., would be the Prime Meridian.

Mercator is an international rectangular coordinate system which extends around the world from 84 degrees North to 80 degrees South. The world is divided into 60 zones, each covering six (6) degrees longitude. Each zone extends three (3) degrees eastwards and three degrees westwards from its central meridian. Zones are numbered west to east from the 180 degree meridian. Because of the small area covered by each zone, a high degree of accuracy is possible. For example, Nepal falls under zones 44 and 45.

Problems arise when a map extends into two UTM zones. The entire map will then have to be projected into one of the two zones.

The advantage of using UTM coordinates is its metric nature. Normal calculations can be performed on UTM coordinates, while for geographic coordinates the minutes and seconds have to be first transformed into the decimal system.

Calculation of a map projection requires definition of the spheroid. As the earth is not a perfect globe (i.e., the earth is 'flattened' at the poles), a spheroid is defined in terms of axes lengths and eccentricity of the earth. Several principal spheroids are in use by one or more countries. Differences are due primarily to calculation of the spheroid for a particular region of the earth's surface. Some important spheroids are the Clarke 1866, the Bessel and the New International 1967. In the HKH Region, in general the Everest spheroid is applied.

Geographic Data

SPOT PAN PANCHROMATIC MODE 20 DEC 1988 KATHMANDU NEPAL

(10 m RESOLUTION) 0.5 to 0.7 micrometers

City Name
Address range to the airport
Address range to the park
Street No., Direction of Travel

Geographic Data

Although the two terms, data and information, are often used indiscriminately, they both have a specific meaning. Data can be described as different observations which are collected and stored. Information is data which is useful in answering queries or solving a problem. Digitising a large number of maps provides a large amount of data after hours of painstaking work, but the data can only render useful information if used in analysis.

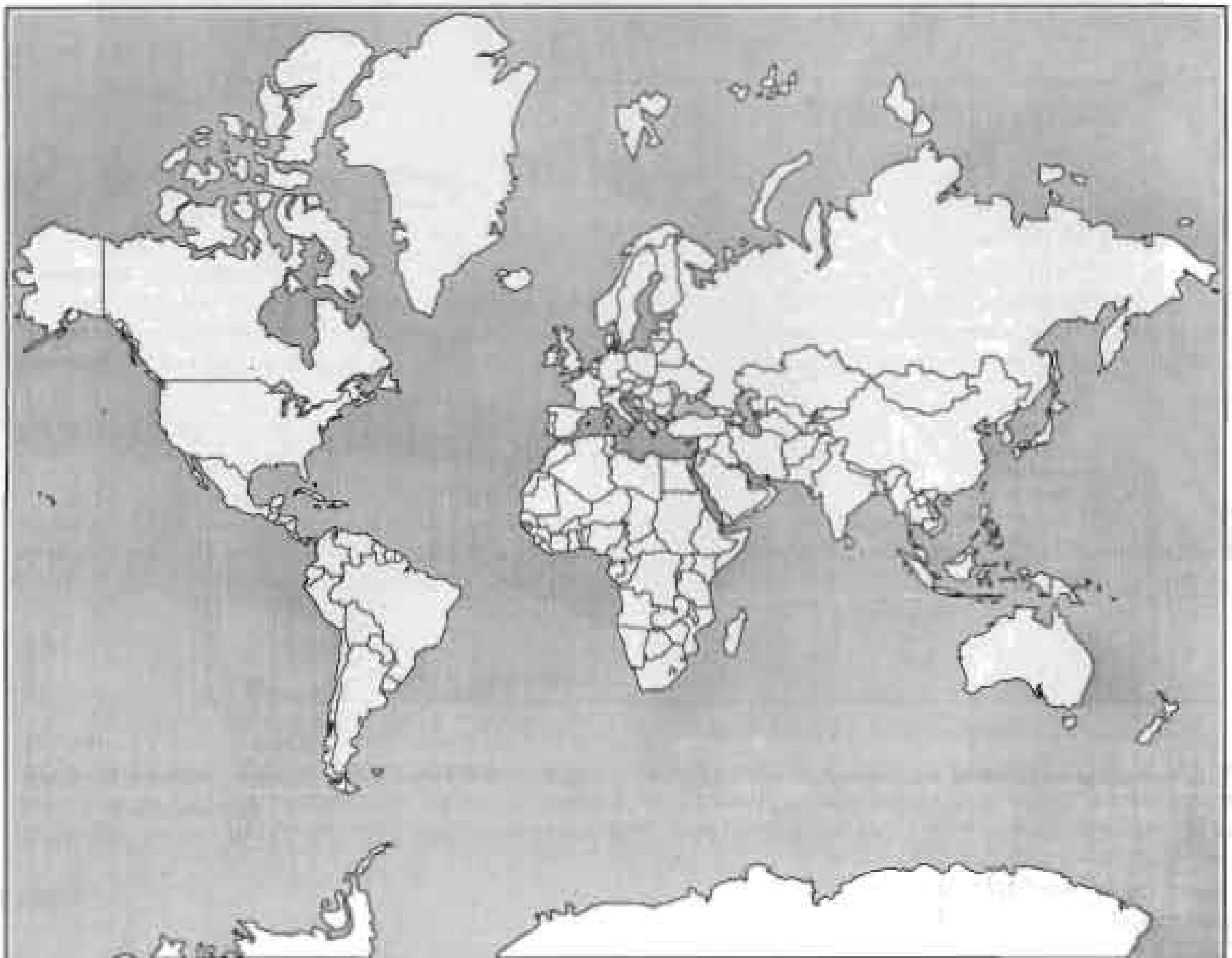
Spatial and Non-Spatial data

Geographic data are organised in a geographic database. This database can be considered to be a collection of spatially referenced data that acts as a model of reality. There are two important components of this geographic database: its **geographic position** and its **attributes or properties**. In other words, spatial data (where is it?) and attribute data (what is it?)

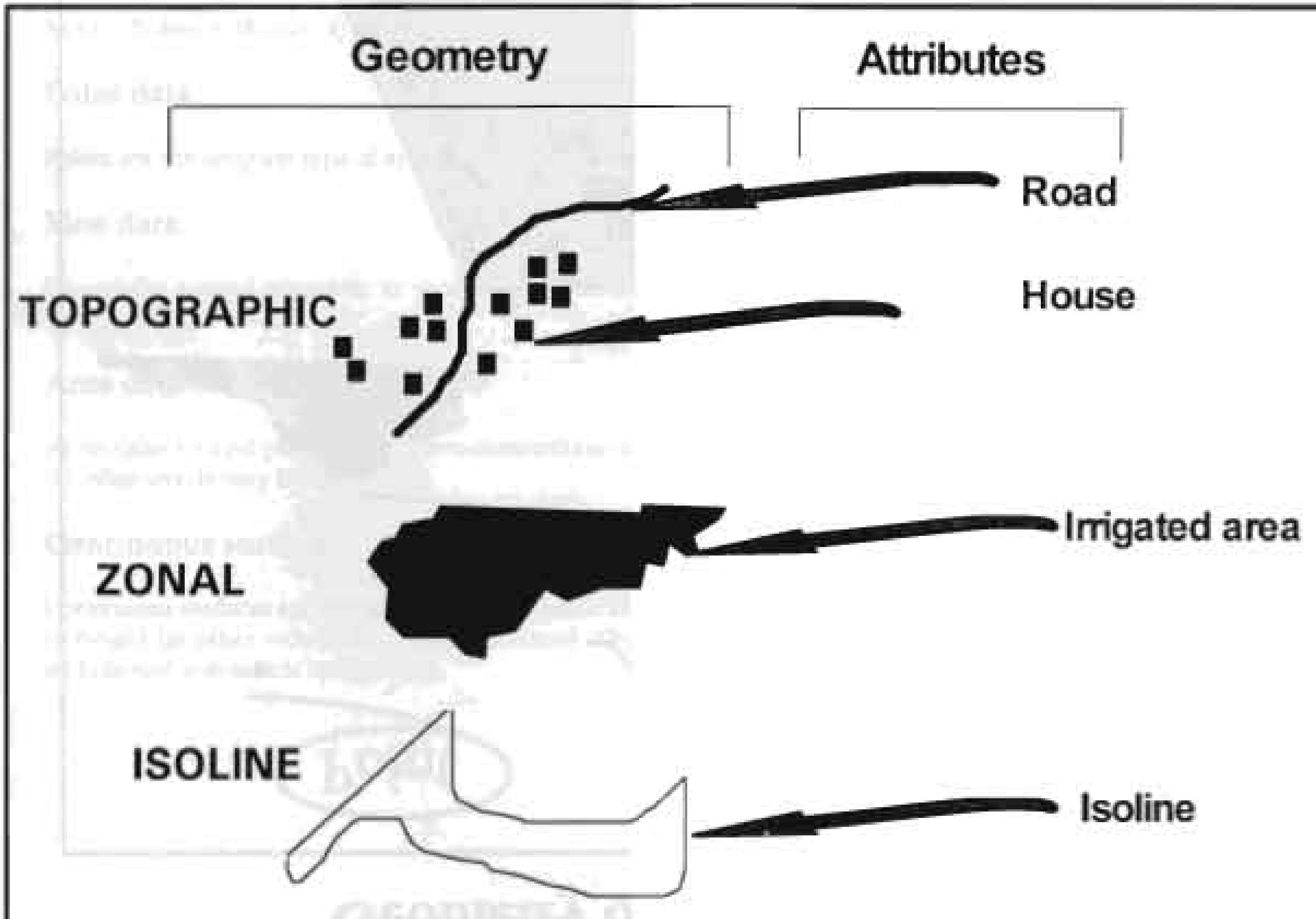
Spatial data

Geographic position refers to the fact that each feature has a location that must be specified in a unique way. To specify the position in an **absolute** way a **coordinate** system is used. For small areas, the simplest coordinate system is the regular square grid. For larger areas, certain approved cartographic projections are commonly used. Internationally, there are many different coordinate systems in use.

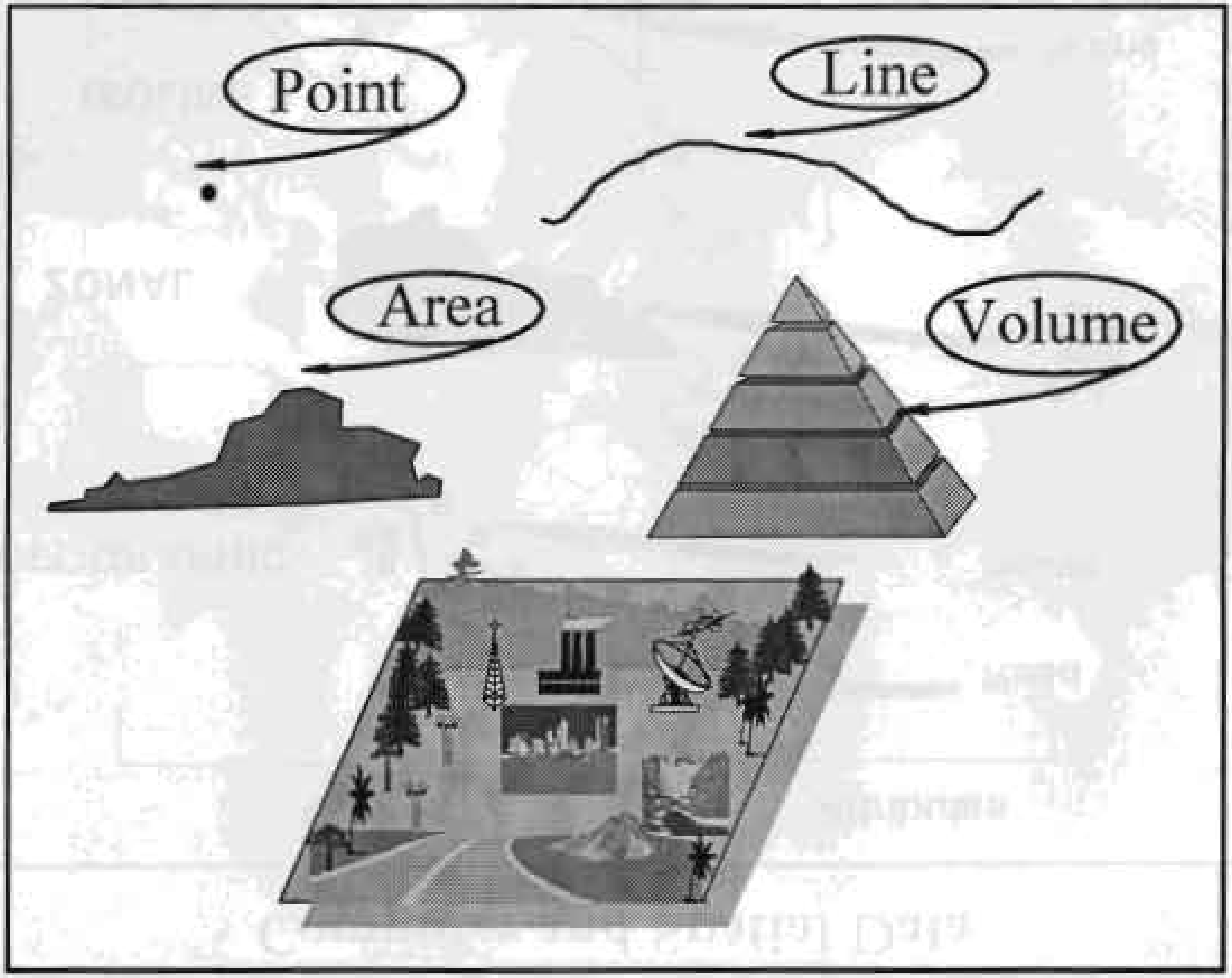
Spatial Data for GIS



Computer and Spatial Data



Geometry of Spatial Data



Basic Types of Spatial data

Most GIS deal with four (4) types of geographic data: points, lines, areas, and continuous surfaces.

Point data

Points are the simplest type of spatial data. They are zero-dimensional objects with only a position in space but no length.

Line data

Lines (also termed segments or arcs) are one-dimensional spatial objects. Besides having a position in space, they also have a length.

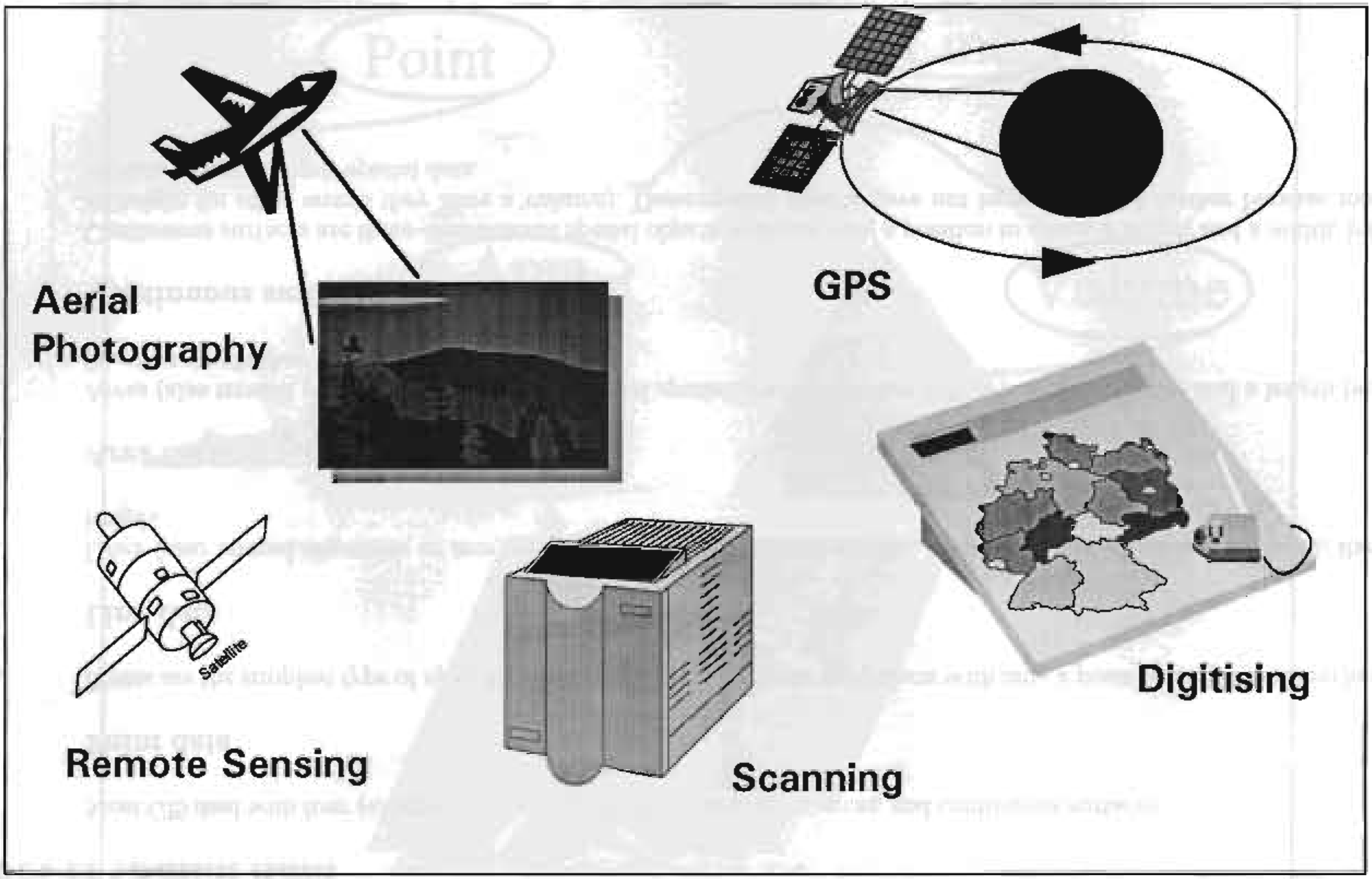
Area data

Areas (also termed polygons) are two-dimensional spatial objects with not only a position in space and a length but also a width (in other words they have an area).

Continuous surface

Continuous surfaces are three-dimensional spatial objects with not only a position in space, a length and a width, but also a depth or height (in other words they have a volume). These spatial objects have not been discussed further because most GIS do not include real volumetric spatial data.

Data Capture



Data Capture

The functionality of GIS, however, relies on the quality of data available, which, in most developing countries, is either redundant or inaccurate. Although GIS are being used widely, effective and effiient means of data collection have yet to be systematically established. The true value of GIS can only be realised if the proper tools to collect spatial data and integrate them with attribute data are available.

The vector data model uses three methods of representing data: points, lines, and polygons, of which the x and y coordinates are stored, together with the relationships between the coordinates, lines, and polygons.

In practically all GIS systems, the conversion from analog maps into digital maps, called digitising, is carried out using the vector data structure. Digitising map data can be carried out in two ways, apart from manually entering the coordinates via the keyboard, which, for obvious reasons, is not very popular: manual digitising and raster to vector conversion.

Attribute Handling

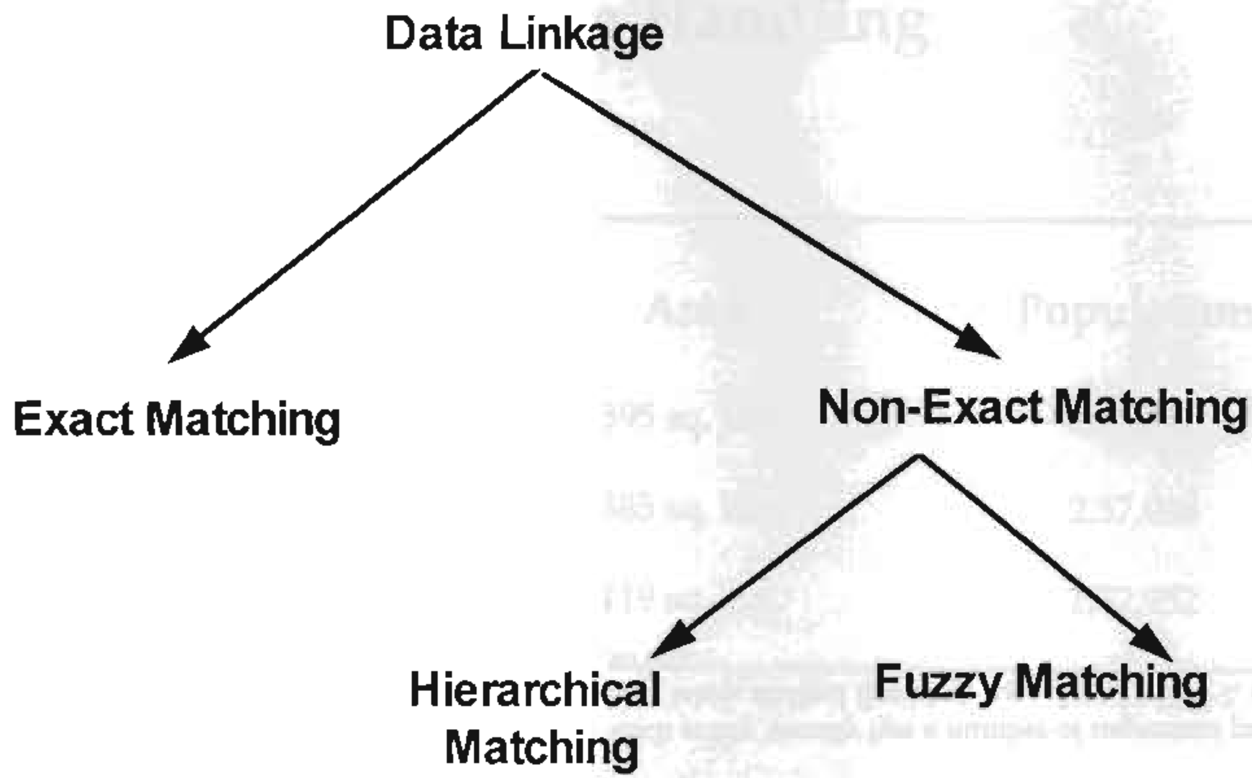
District Name	Area	Population
Kathmandu	395 sq. km.	6,75,341
Lalitpur	385 sq. km.	2,57,086
Bhaktapur	119 sq. km.	1,72,952

Attribute data

The attributes refer to the properties of spatial entities. They are often referred to as non-spatial data since they do not in themselves represent location information.

In addition to the spatial representation of a feature, each entity usually has a number of important properties or attributes. These attributes may be nominal (identity, e.g., maize, granite, lake), ordinal (ranking, e.g., class 1, class 2, class 3, and so on), or scalar (value, e.g., water depth, elevation, erosion rate, and so on).

Data Linkage



Data Linkage

A GIS typically links different sets. Suppose you want to know the mortality rate due to cancer among children under 10 years of age in each country. If you have one file that contains the number of children in this age group, and another that contains the mortality rate from cancer, you must first combine or link the two data files. Once this is done, you can divide one figure by the other to obtain the desired answer.

Exact Matching

Name	Population
Aenchok	4038
Baireni	7030
Naubesi	10777
Salyantar	5798
Gajuri	5606

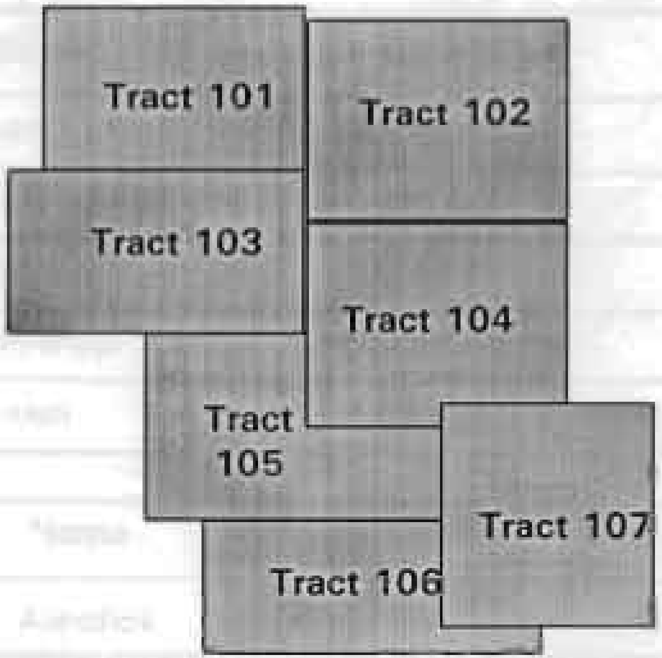
Name	Avg. Housing Cost
Aenchok	30,500
Baireni	22,000
Naubesi	100,000
Salyantar	24,000
Gajuri	24,000

Name	Population	Avg. Housing Cost
Aenchok	4038	30,500
Baireni	7030	22,000
Naubesi	10777	100,000
Salyantar	5798	24,000
Gajuri	5606	24,000

Exact Matching

Exact matching occurs when you have information in one computer file about many geographic features (e.g., towns) and additional information in another file about the same set of features. The operation to bring them together is easily achieved by using a key common to both files – in this case, the town name. Thus, the record in each file with the same town name is extracted, and the two are joined and stored in another file.

Hierarchical Matching



Kathmandu District

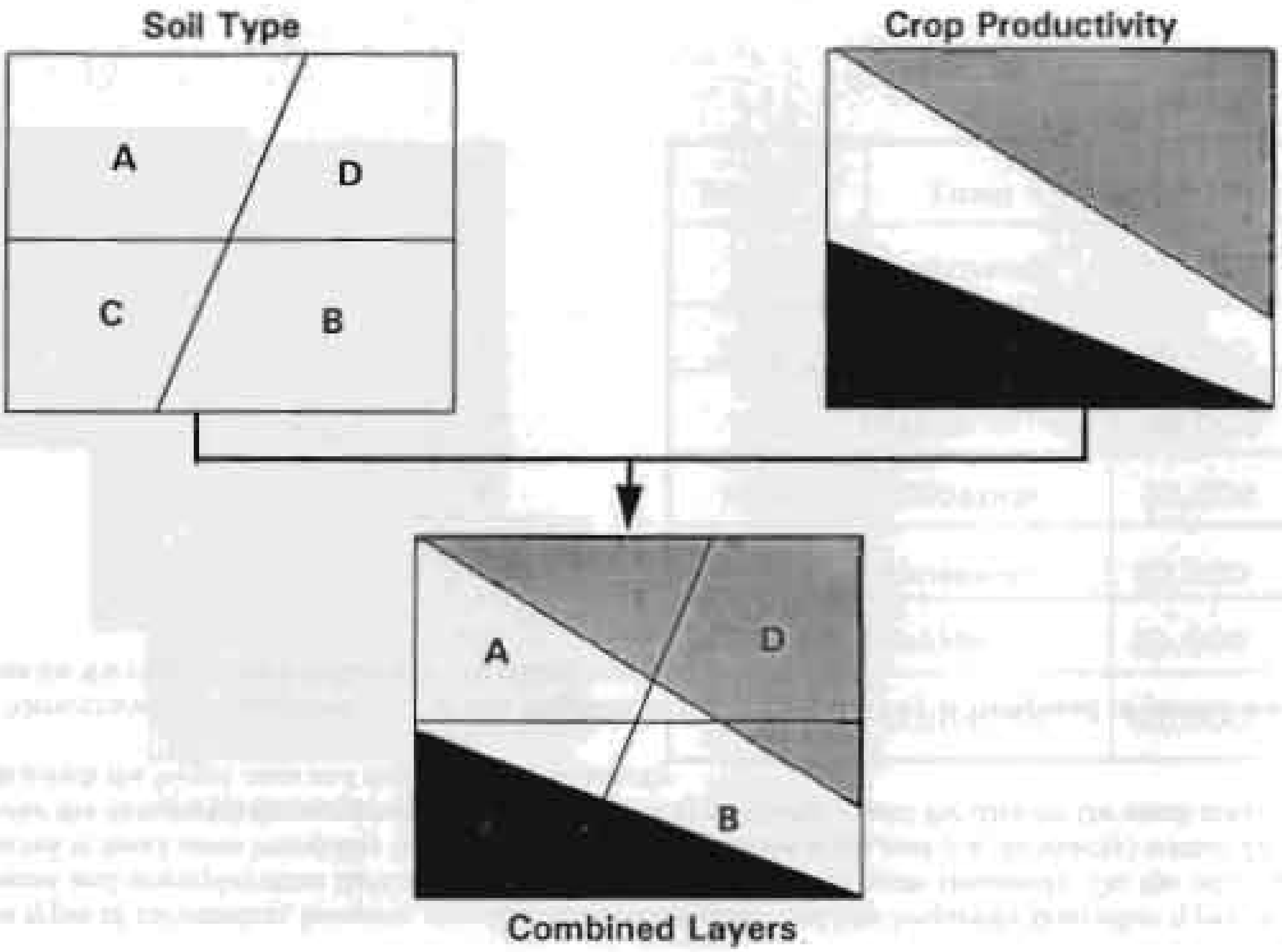
Tract	Town	Population
101	Kathmandu	60,000
102	Maharangung	45,000
103	Patan	35,000
104	Dillibazaar	36,000
105	Baneswor	57,000
106	Nakkhu	25,000
107	Kupondole	58,000

Hierarchical Matching

Some types of information, however, are collected in more detail and less frequently than other types of information. For example, financial and unemployment data covering a large area are collected quite frequently. On the other hand, population data are collected in small areas but at less frequent intervals. If the smaller areas nest (i.e., fit exactly) within the larger ones, then the way to make the data match the same area is to use hierarchical matching — add the data for the small areas together until the grouped areas match the bigger ones and then match them exactly.

The hierarchical structure illustrated in this diagramme shows that this city is composed of several tracts. To obtain meaningful values for the city, the tract values must be added together.

Fuzzy Matching



When data boundaries between layer do not match, the layers can be jointed, creating a new layer containing the characteristics of both layers.

Fuzzy Matching

On many occasions, the boundaries of the smaller areas do not match those of the larger ones. This occurs often while dealing with environmental data. For example, crop boundaries, usually defined by field edges, rarely match the boundary between soil types. If you want to determine the most productive soil for a particular crop, you need to overlay the two sets and compute crop productivity for each and every soil type. In principle, this is like laying one map over another and noting the combinations of soil and crop productivity.

A GIS can carry out all of these operations because it uses geography, or space, as a common key between the data sets. Information is linked only if it relates to the same geographical area.

Why is data linkage so important? Consider a situation where you have two data sets for a given area, such as yearly income by county and average cost of housing for the same area. Each data set might be analysed and/or mapped individually. Alternatively, they may be combined. With two data sets, only one valid combination exists. Even if your data set may be meaningful for a single query you will still be able to answer many more questions than if the data sets were kept separate. By bringing them together, you add value to the database. To do this, you need GIS.

Four Major GIS Functions

- data capture
  - graphic data: digitised, converted from existing data
  - attribute data: keyed-in, loaded from existing data files

- data storage and manipulation
  - file management
  - editing

- data analysis
  - database query
  - spatial analysis
  - modelling

- data display
  - maps
  - reports

Major Functions of GIS

Data Capture. Data used in GIS often come from many different sources, are of many types, and are stored in different ways. A GIS provides tools and a method for the integration of different data into a format to be compared and analysed. Data sources are mainly manual digitisation/scanning of aerial photographs, paper maps, and existing digital datasets. Remote-sensing satellite imagery and GPS are promising data input sources for GIS.

Database Management and Update. After data are collected and integrated, the GIS must provide facilities which can contain and maintain data. Effective data management has many definitions but should include all of the following aspects: *data security, data integrity, data storage* and *retrieval*, and *data maintenance abilities*.

Geographic Analysis. Data integration and conversion are only a part of the input phase of GIS. What is required next is the ability to interpret and to analyse the collected information quantitatively and qualitatively. For example, a satellite image can assist an agricultural scientist to project crop yield per hectare for a particular region. For the same region, the scientist also has the rainfall data for the past six months collected through weather station observations. The scientist also has a map of the soils for the region which shows fertility and suitability for agriculture. These point data can be interpolated and what you get is a thematic map showing isohyets or contour lines of rainfall.

Presenting Results. One of the most exciting aspects of GIS technology is the variety of different ways in which the information can be presented once it has been processed by GIS. Traditional methods of tabulating and graphing data can be supplemented by maps and three dimensional images. Visual communication is one of the most fascinating aspects of GIS technology and is available in a diverse range of output options.

Types of GIS

- Vector GIS
- Raster GIS
- Hybrid GIS

Technology is moving towards hybrid GIS

Raster Vector Integration

Representation of Geographic Data

The representation of geographic data is primarily driven by the types of data structure. This is often termed a data model. A data model is a formal system in which a set of precisely defined objects can be manipulated in accordance with a set of precisely predefined rules, without any regard for the 'meaning' or real-world interpretation of those objects or rules. Reality is an informal system, a system of immense complexity and a system with an infinite amount of information. The difficulty in defining a comprehensive and useful data model is to find a formal system whose behaviour mimics the informal behaviour of the real world as closely as possible

A GIS data model, often known as a geo-relational model, is a formal collection of spatial operators that act on a spatial database in order to relate the user to the real world. GIS uses primarily two spatial data models: **vector and raster**.

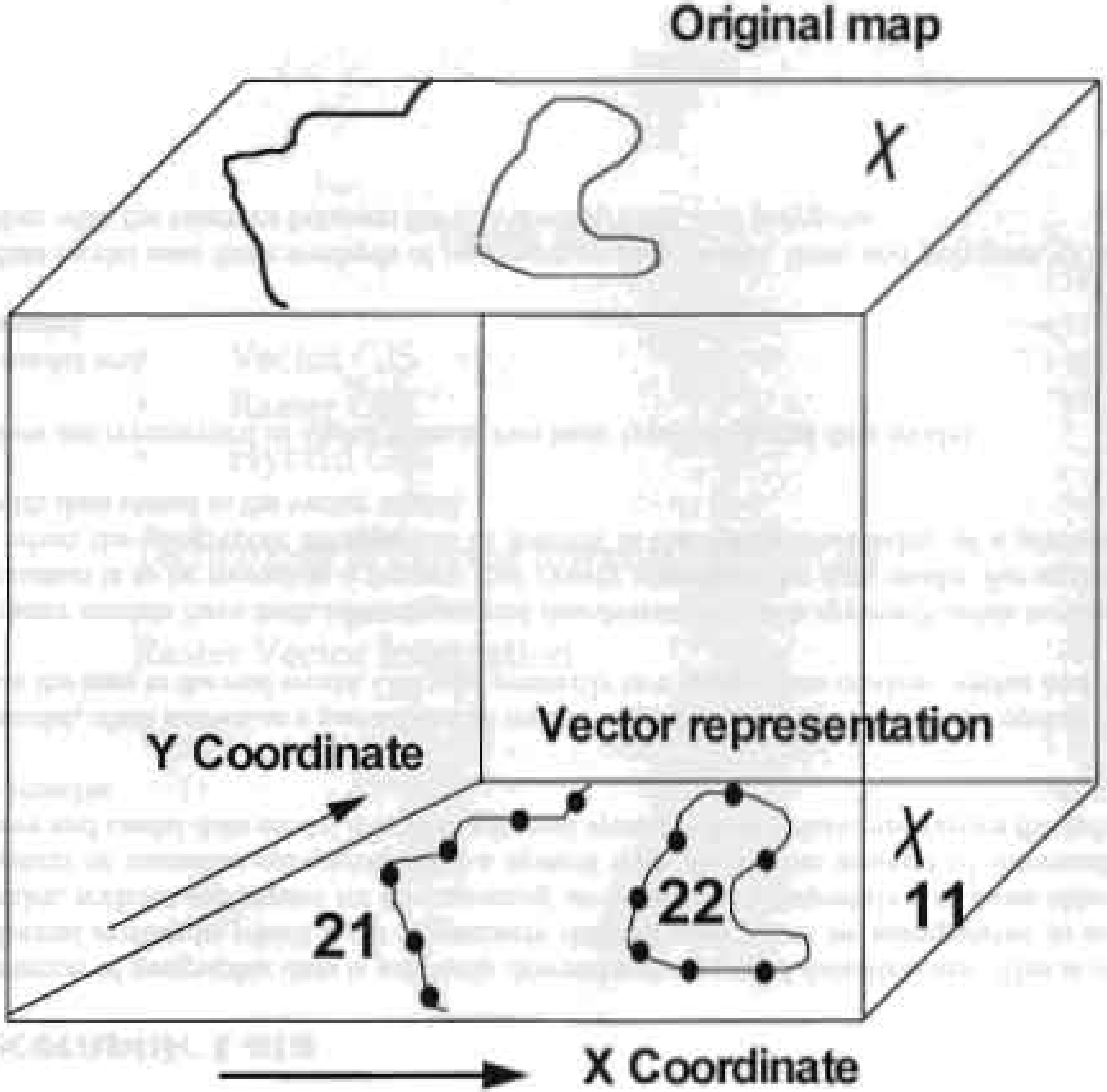
Vector and raster models have both advantages and disadvantages. Each approach tends to work best in situations in which the spatial information is to be treated in a manner that closely resembles the data model. For example, the raster model is generally well suited when the geographic information of interest is the spatial variability of a phenomenon; network analysis is best performed with data stored in the vector model.

The spatial data are represented in digital form in two basic types of spatial data model.

- **a vector model** and
- **a raster model.**

The vector data model uses three methods of representing data: points, lines, and polygons, of which the x and y coordinates are stored, together with the relations between the coordinates, lines, and polygons.

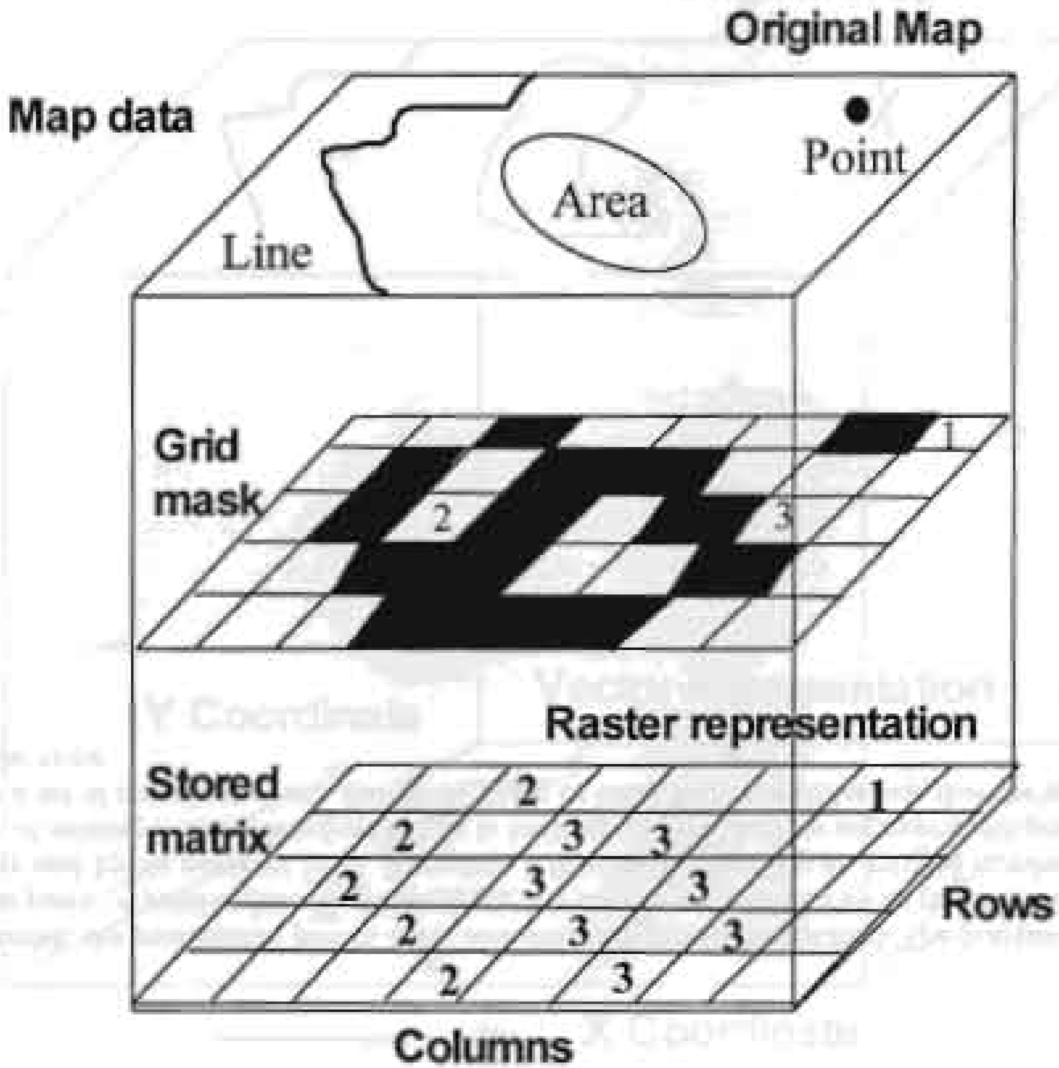
Vector Representation



The vector Model

In a vector model, the positions of points, lines, and areas are precisely specified. The position of each object is defined by a (series of) coordinate pairs. A *point* is described by a single X-Y coordinate pair and by its name or label. A **line** is described by a set of co-ordinate pairs and by its name or label. In reality, a line is described by an infinite number of points. In practice, this is not a feasible way of storing a line. Therefore, a line is built up of straight line segments. An *area,* also called a *polygon,* as a line is described by a set of coordinate pairs and by its name or label, with the difference that the coordinate pairs at the beginning and the end are the same.

Raster Representation



The raster model

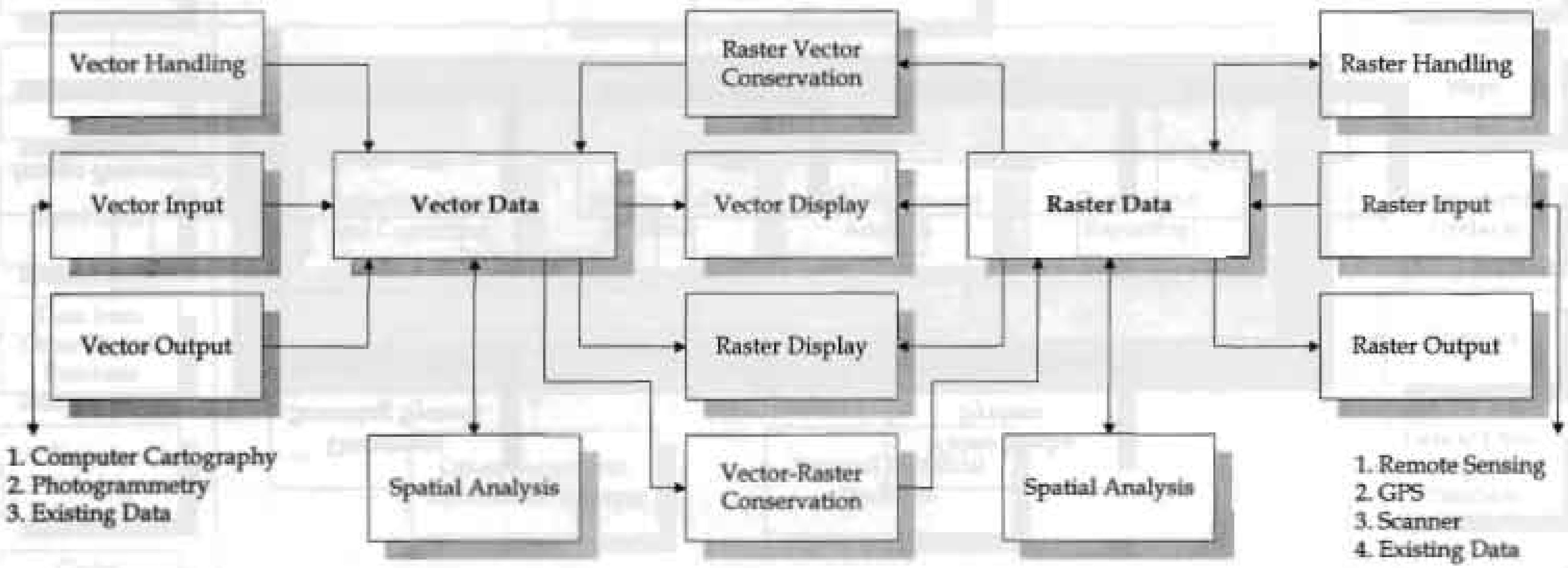
The simplest way of storing spatial data is through the raster model. In this model, the spatial data are organised in cells or pixels (hereafter referred to as pixels). These pixels are the basic units for which information is explicitly recorded. Each pixel is only assigned one value.

A *point* is described by the position of a single pixel. Usually, the position of the cell is defined by a row and column number. A pixel is assigned one numerical value. The name of the point is not explicitly recorded within the pixel itself. A legend has to be available to determine which name belongs to which digital number. A *line* and an *area* are described by a set of connected pixels with one numerical value. In the raster model there is no basic difference in how points, lines, and areas are stored.

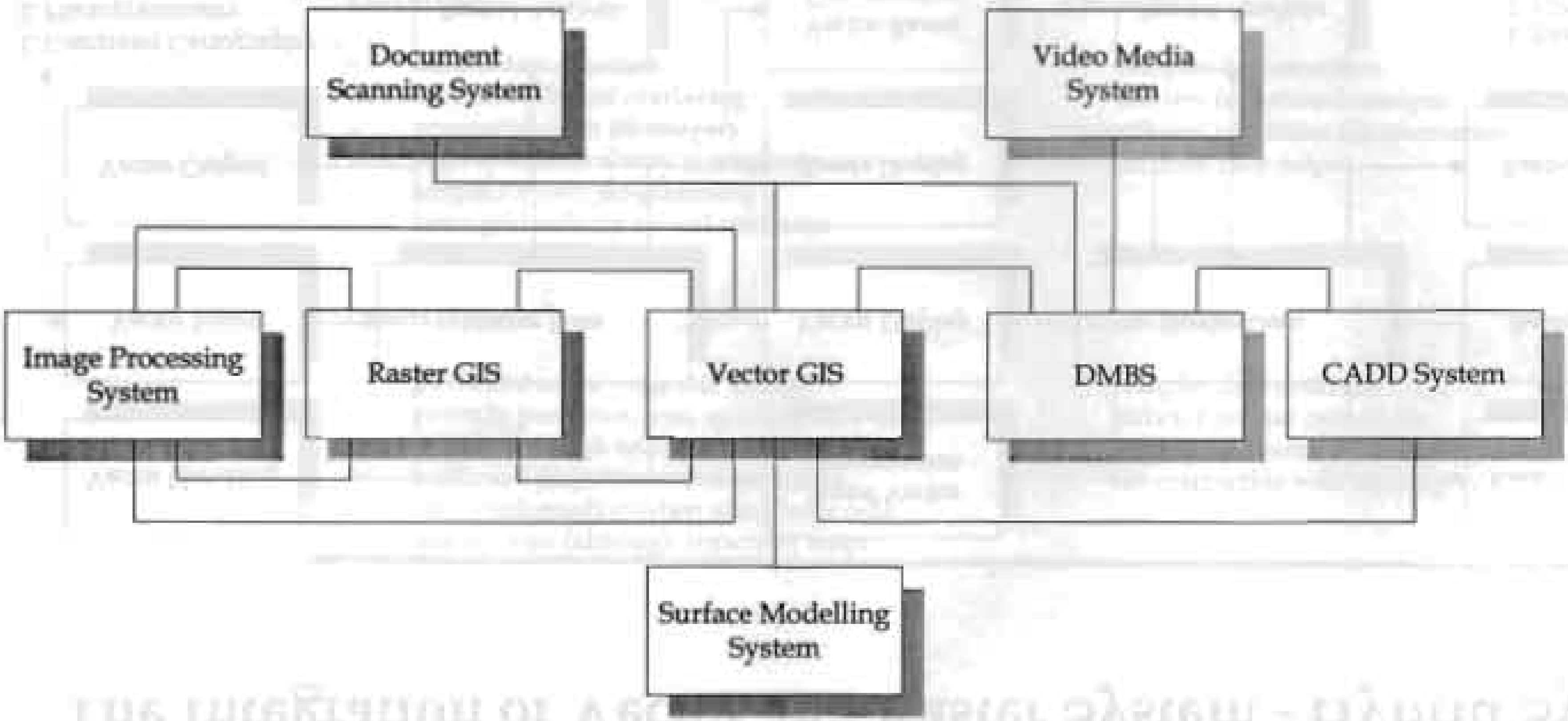
Advantages and Disadvantages of the Raster and Vector Data Models

RASTER MODEL	VECTOR MODEL
Advantages	**Advantages**
- simple data structure	- compact data structure
- easy and efficient overlaying	- efficient for network analysis
- compatible with RS imagery	- efficient projection transformation
- high spatial variability is efficiently represented	- accurate map output
- simple for own programming	
- same grid cells for several attributes	
Disadvantages	**Disadvantages**
- inefficient use of computer storage	- complex data structure
- errors in perimeter, area, and shape	- difficult overlay operations
- difficult network analysis	- high spatial variability is inefficiently represented
- inefficient projection transformations	- not compatible with RS imagery
- loss of information when using large cells	
- less accurate (although attractive) maps	

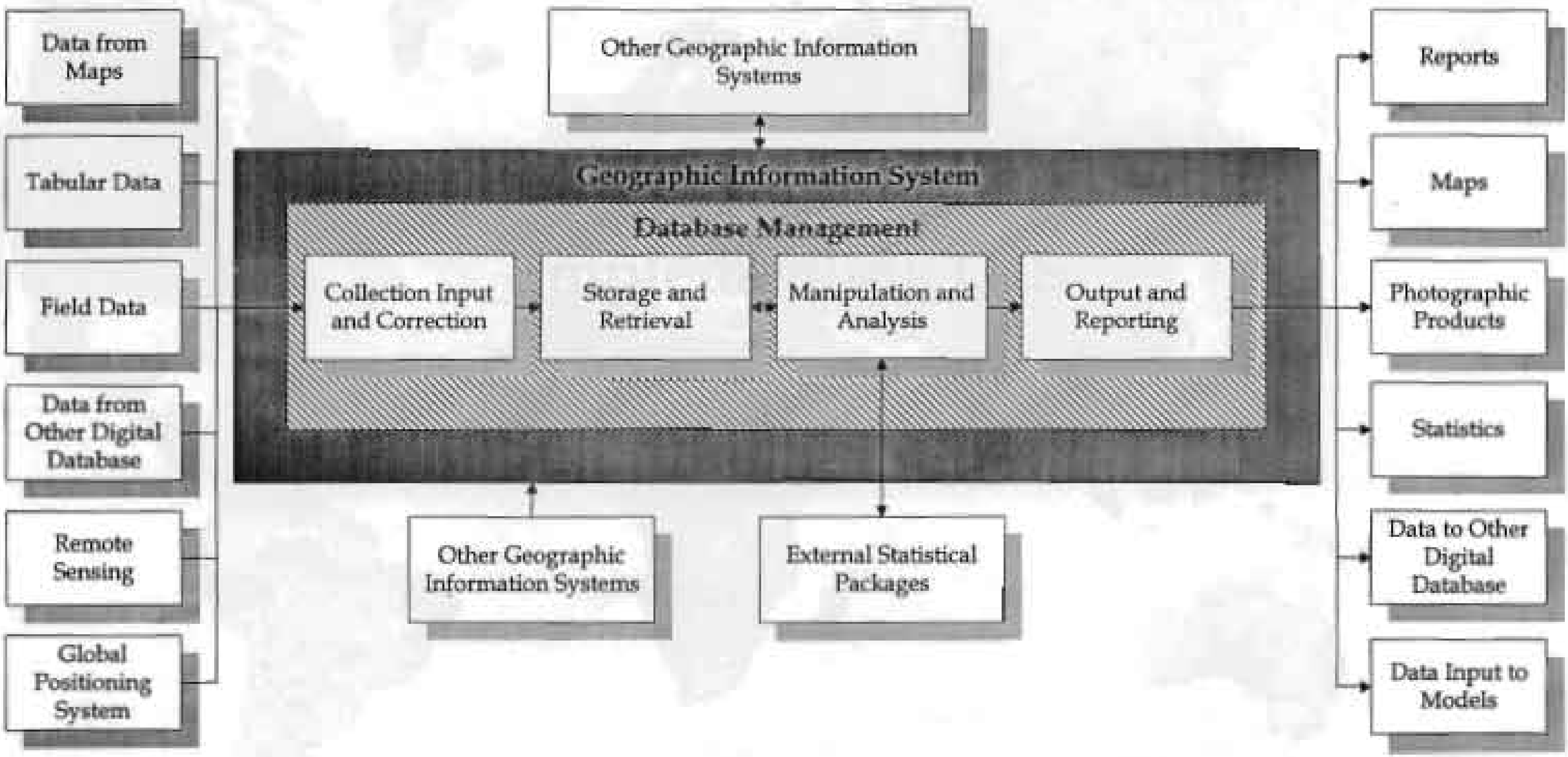
The Integration of Vector and Raster System - Hybrid System



An Example of Raster and Vector Integration



Principal Components and Functions of an Ideal GIS



An Example of Raster and Vector Integration

Chapter 4

Implementing GIS

Implementing GIS

- Establishment Phase
    - hardware/software
    - trained manpower
    - pilot study
- Application Development Phase
    - Database Standards
    - Database Development
    - GIS Applications

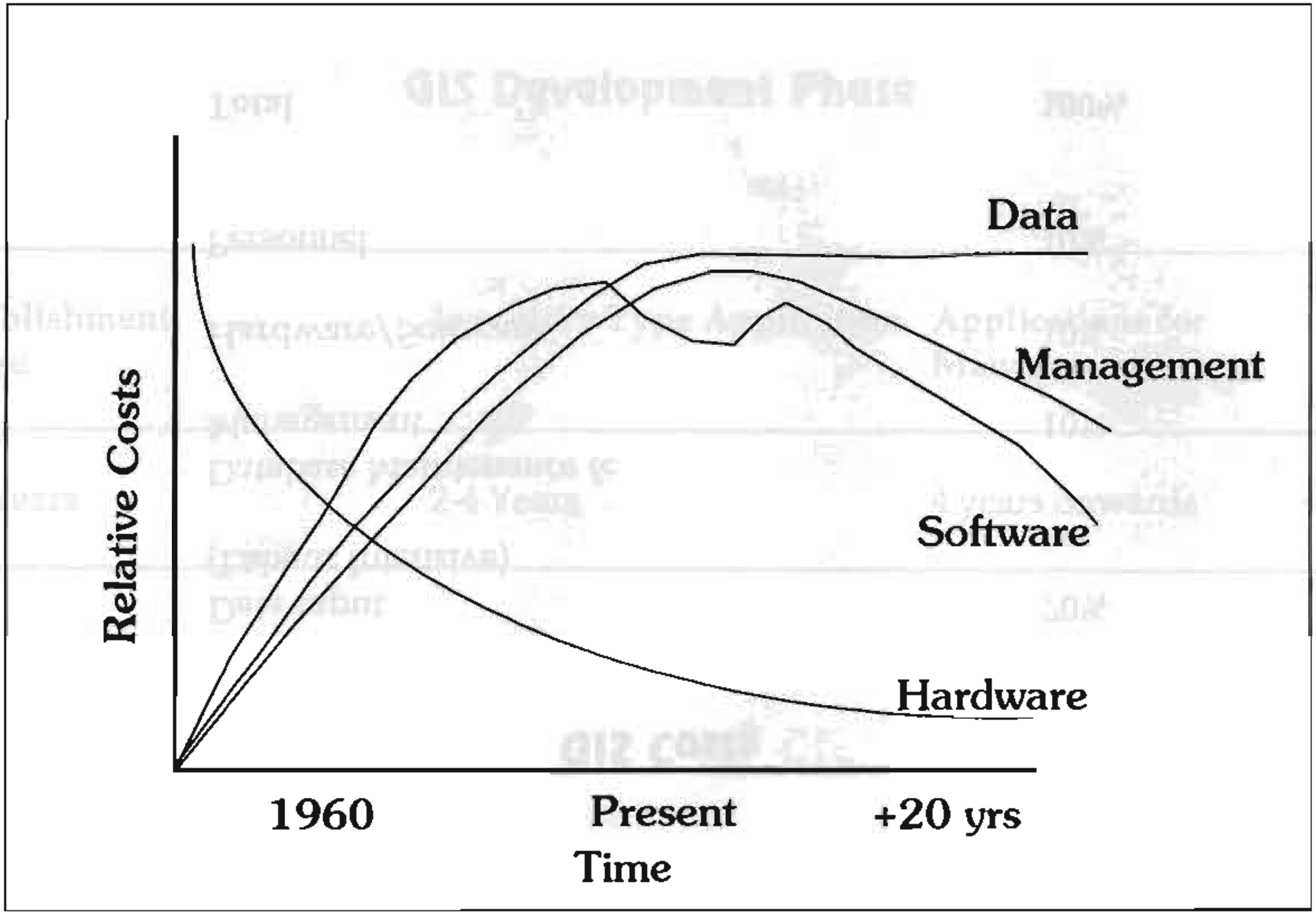
GIS Development Phase

Establishment Phase	Inventory Type Application	Applications for Management
1-2 Years	2-4 Years	4 years onwards

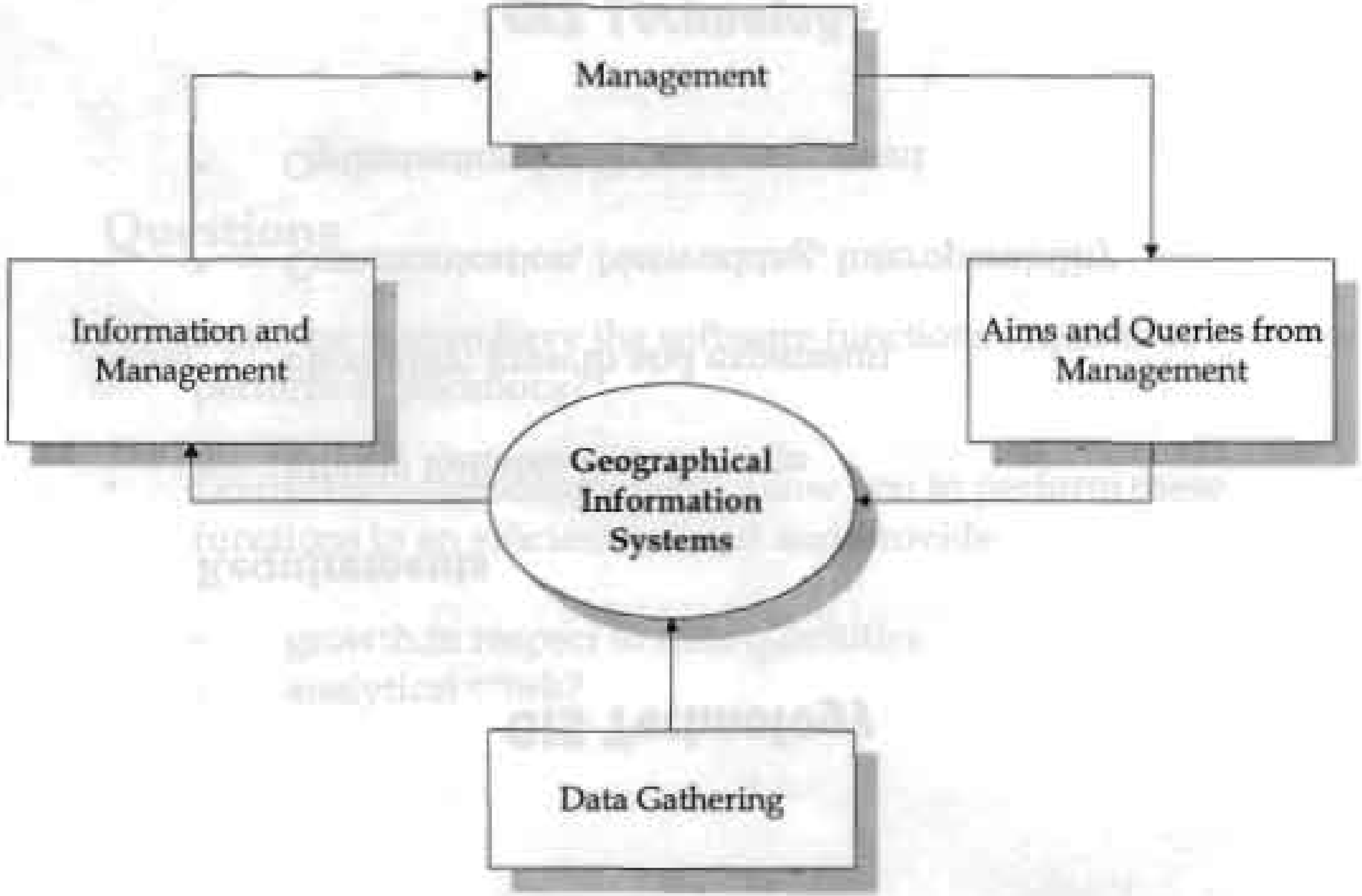
GIS Costs

Data Input (Labour Intensive)	70%
Database Maintenance & Management	10%
Hardware/Software	10%
Personnel	10%
Total	**100%**

Costs of GIS


Data
Management
Software
Hardware
Relative Costs
1960
Present
+20 yrs
Time

Organisational Aspects of GIS



GIS Technology

Requirements

- Highly Reliable Data Storage
- Flexibility: growth and expansion
- Communication, Networking, Interoperability
- Optimisation for Data Management

GIS Technology

Questions

- Does the system have the software functions required to perform applications?
- Do the hardware components allow you to perform these functions in an efficient manner and provide:
    - growth in respect to data quantities
    - analytical work?

GIS Technology Trend

- Corporate GIS
- Desktop GIS

- Data Transparency
- User Transparency

GIS Technology Trends

- Computer Technology
  - Distributed Computing

    Client-Server Architecture
    Multitasking Capability
  - High Quality Graphics

    3-D or Topographic modelling
  - Network Environment

    Network Transparency
  - Graphical User Interface

    User-friendly Software
    Usability Engineering

GIS Technology Trends

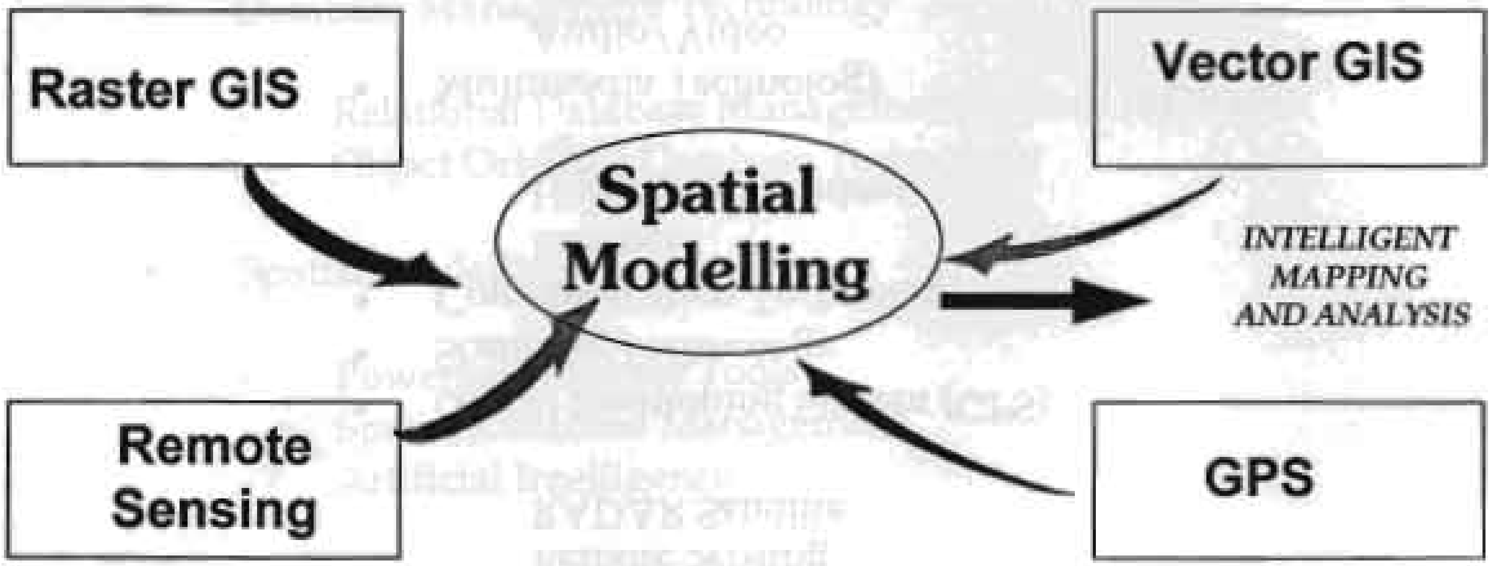
- Database Management Technology
  - Relational Database Management System (RDBMS)
  - Object Oriented Database Technology
- Spatial Modelling
  - Powerful Software Tools
  - Spatial Database Management
  - Artificial Intelligence

    Neural Networks
    Expert Systems

GIS Technology Trends

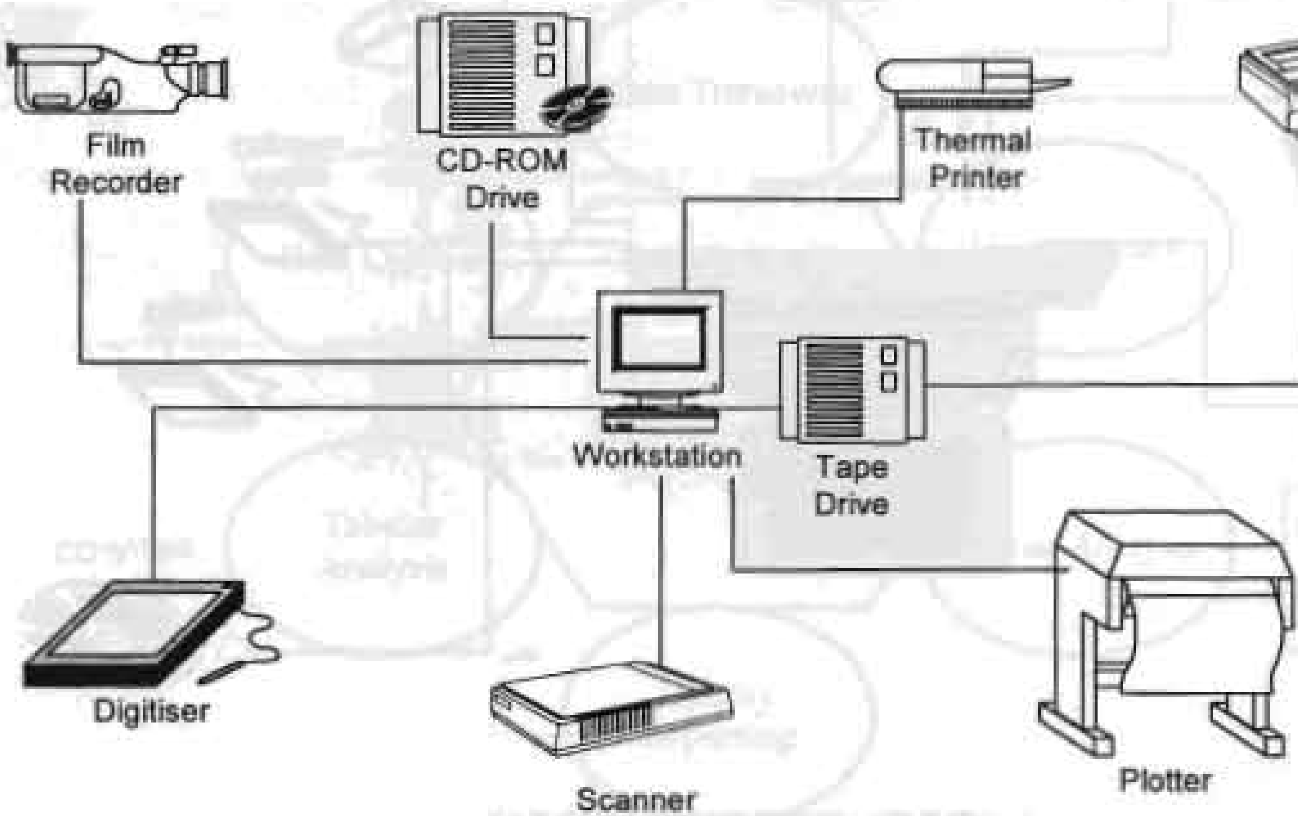
- Satellite Technology
  - Remote Sensing
  - RADAR Satellite
- Global Positioning System (GPS)
- Scanning Technology
- Communication Technology
  - Internet
  - High Speed Modem
- Multimedia Technology
  - Audio/Video
  - CD-ROM
- Printing Technology
  - True Colour Printing Capability

Integration of GIS Technology

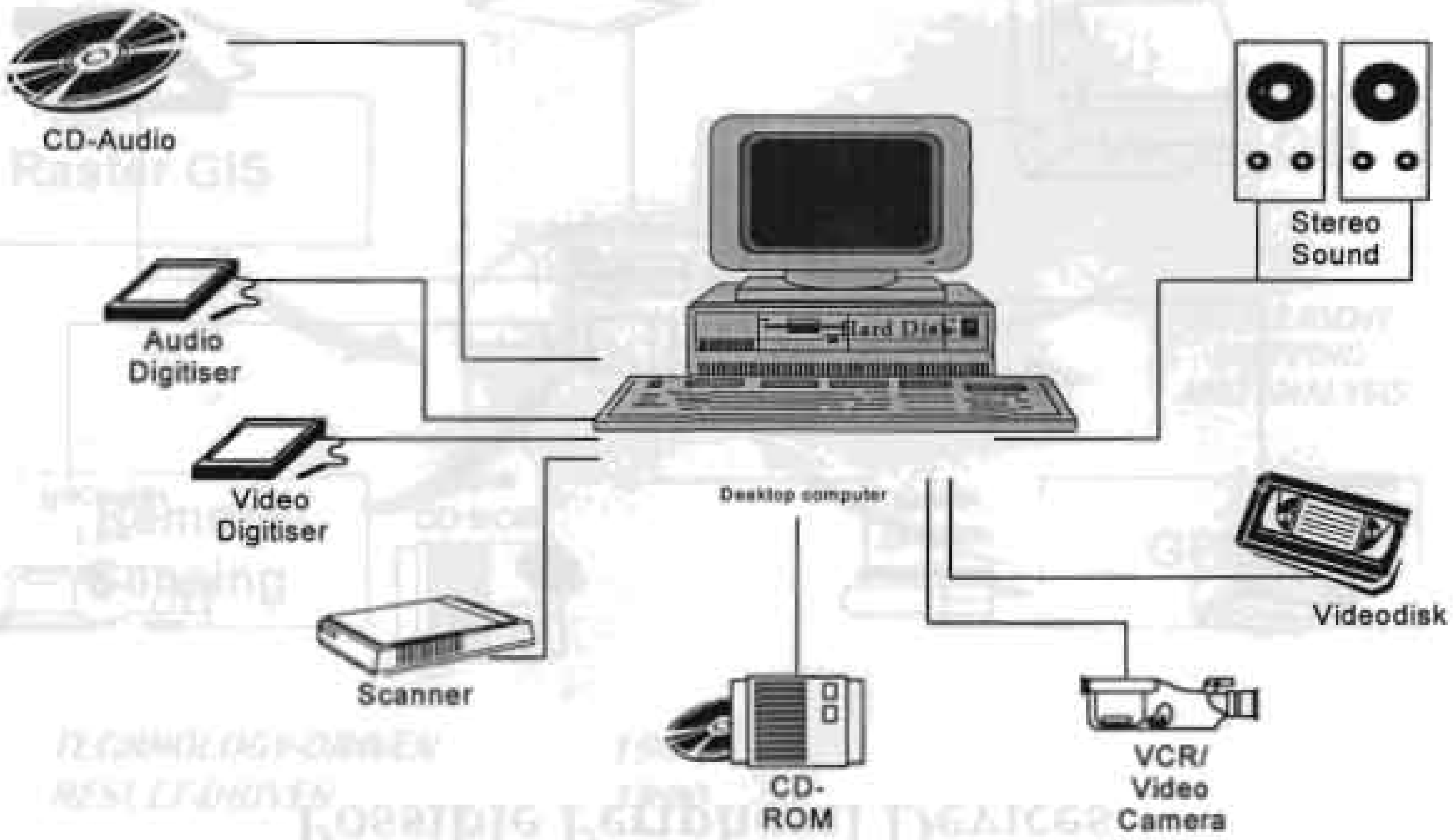


TECHNOLOGY-DRIVEN *1980*
RESULT-DRIVEN *1990*

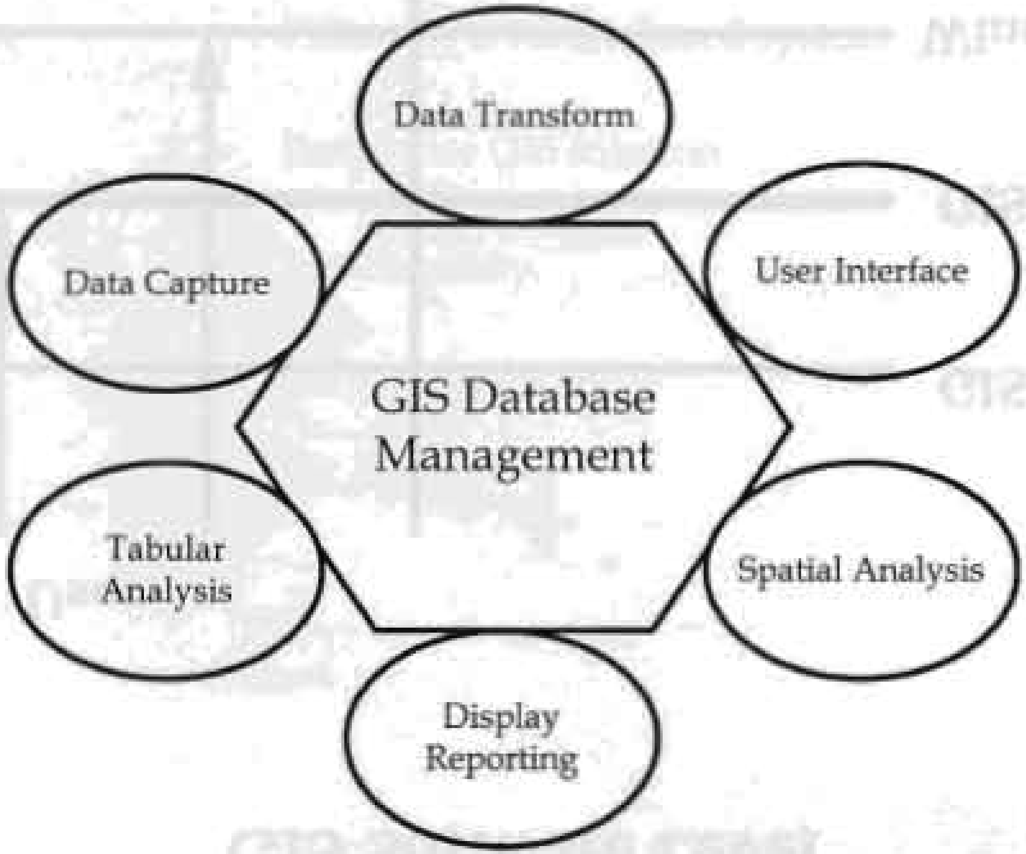
Possible Peripheral Devices



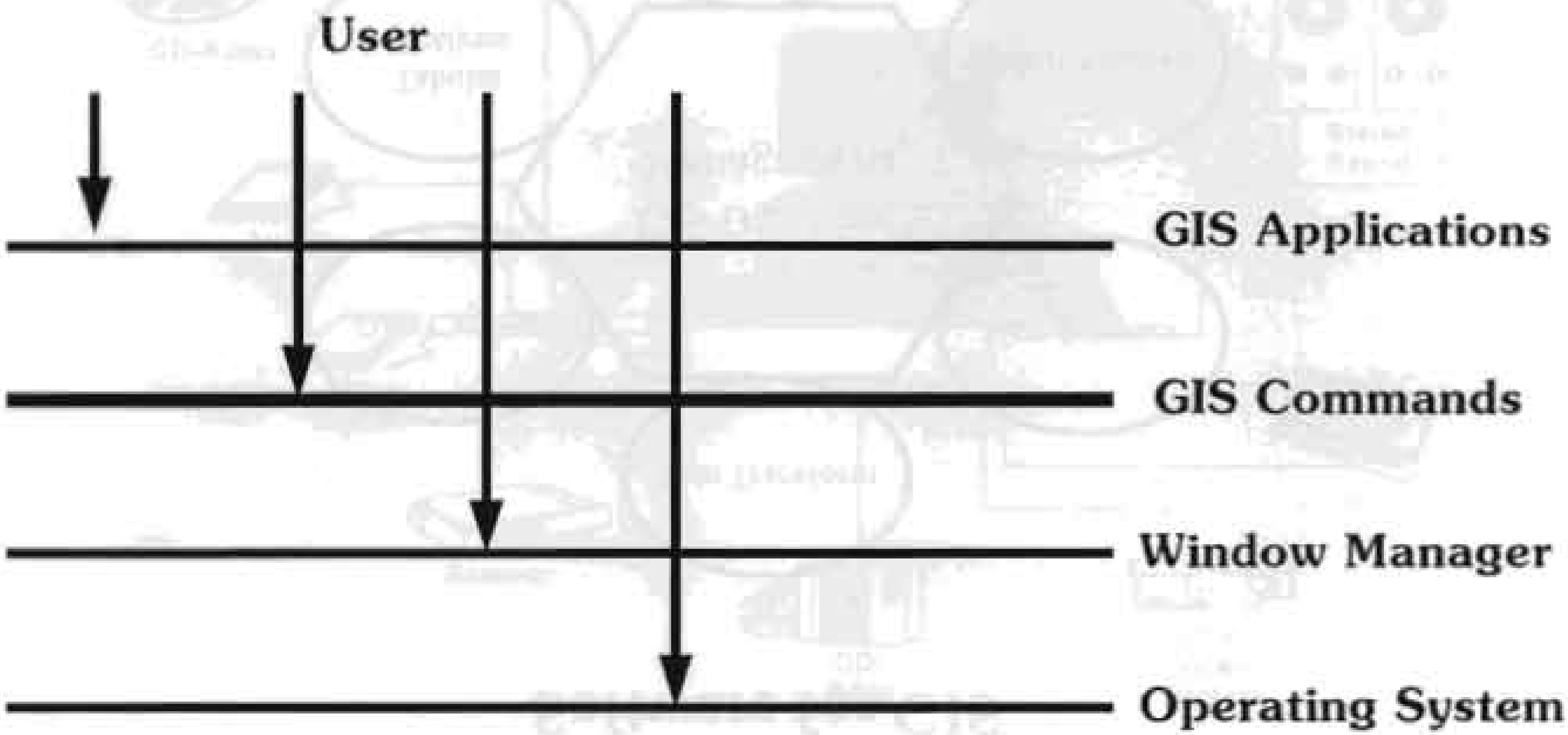
Multimedia GIS



Software for GIS



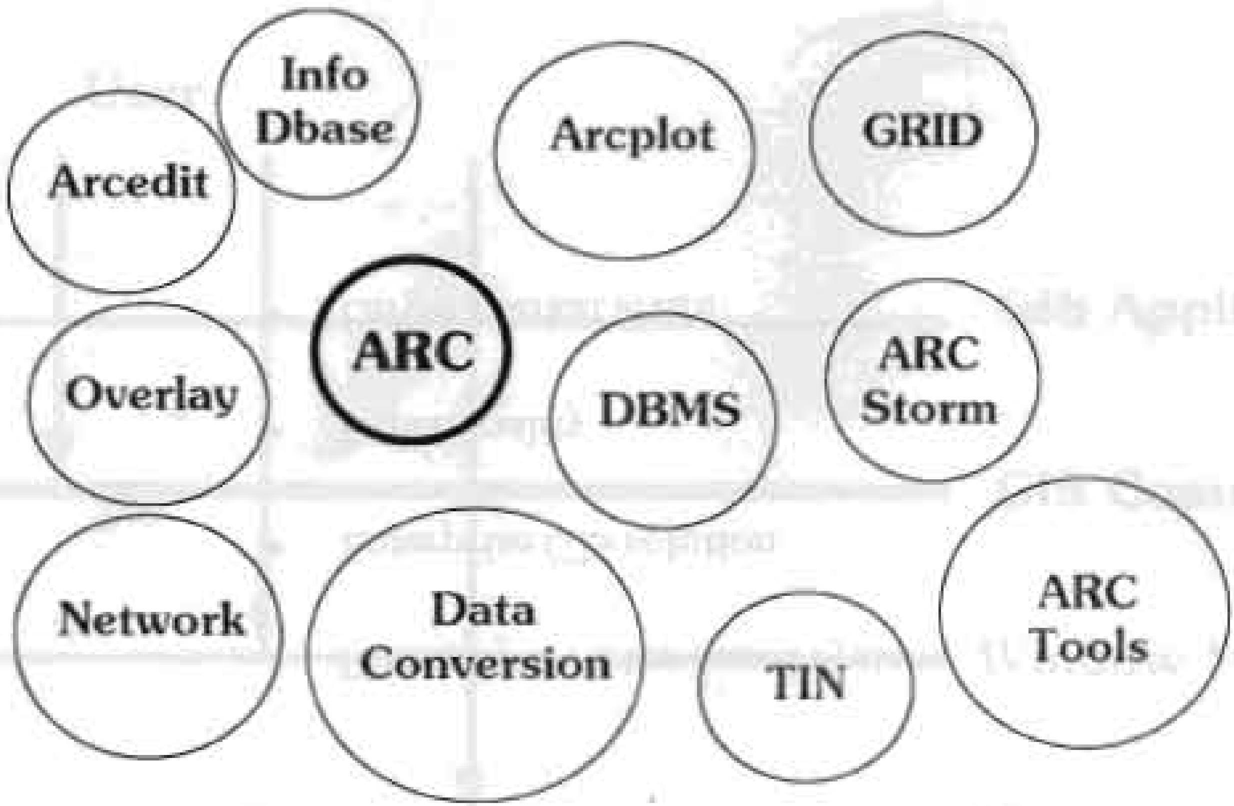
GIS Software Level



Arc/Info

- Primarily a vector-based system
- Enterprise GIS solution
- Functionality
- Larget market share

Arc/Info Modules



ArcView

- Display and Query GIS Database
- Windows' - based software
- Presentation
- Graphical User Interface
- Options for Raster data

GIS Trends In The Commercial Sector

Project-oriented GIS uses	➡	Database-oriented GIS uses
Mainframe-based GIS	➡	Mini-Computer-based GIS
Minicomputer-based GIS	➡	Workstation/ Personal Computer-based GIS
Small area databases	➡	Global databases
Isolated users	➡	Networked users.

National GIS Considerations

- Steering Committee
  - A Policy Board
  - Local User Representation
  - University Representation

- Coordinating Agency
  - Training
  - Database Standards and Development
  - Data Distribution and Archiving
  - Technical Advice and Hardware/Software

...Contd.

- Success Stories and Pilot Studies
  - Successful GIS Strategies
  - Local-level Pilot Study
  - Regional-level Pilot Study
  - National-level Pilot Study
- Implementation Strategy and Growth Plan
- Annual Programme of Information Sharing and Programme Assessment

Policy Formation Consideration

- Result Driven Vs. Technology Driven
- Education/Training
- Institutional Framework/Initiative
- Standardisation
- Data Standards

A successful GIS implementation demands a paradigm shift at the Policy and Institutional level

GIS System Development Phase

- Awareness
- Development of System Requirements
- System Evaluation
- Implementation Plan

Database Issues

- Data Standards
- Data Sensitivity
- Data Quality
- Data Dissemination Procedures
- Database Management and Update

GIS Challenges

- Data Capture
- Data Modelling
- Accuracy
- Volume
- Analysis
- User Interfaces
- Costs and Benefits
- Impact on Organisations
- Education and Training

Implementation Alternatives

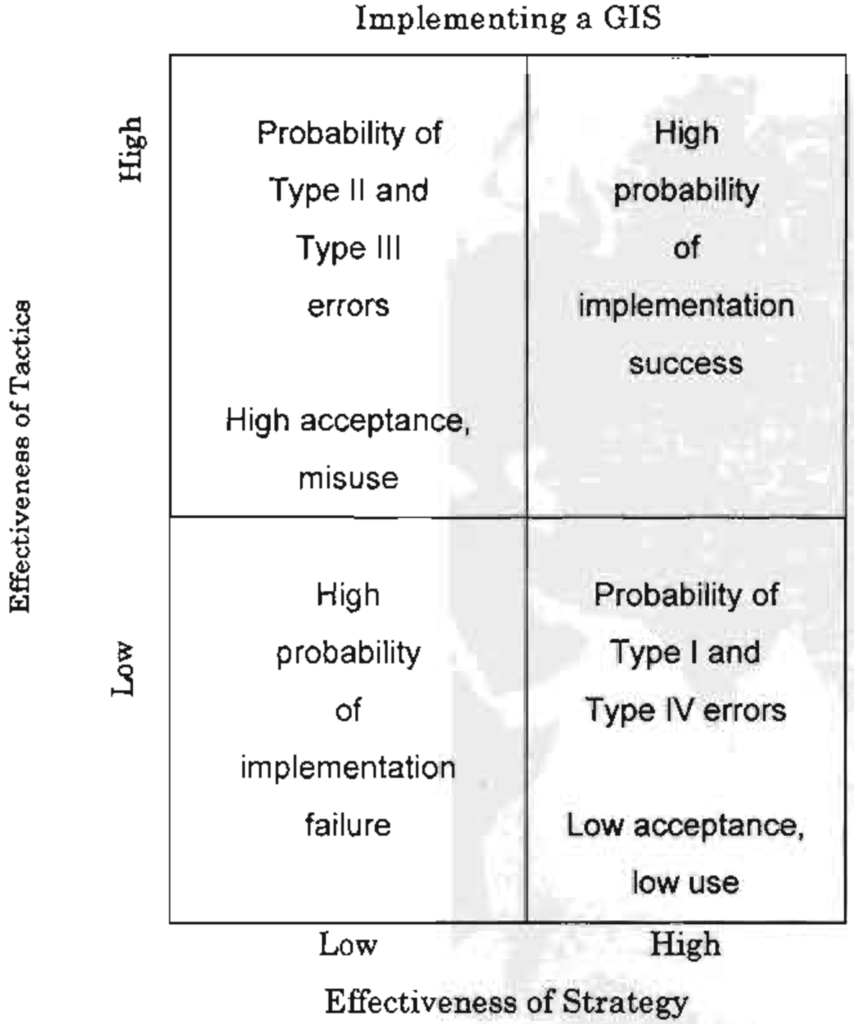
Considerations	User Creates System	Buy Some Software	Buy Complete Software Package	Buy complete Software and Hardware Packages	Purchase GIS Services
Dependence on supplier	Very low	Low	High	Very High	Nearly Complete
Time until system functions	Long	Long to Moderate	Short	Very Short	Not a problem
Initial cost	Low	Moderate	Moderate	High	High
Labour costs paid by user	High	Lower	Moderate	Moderate	Very low
Risk and uncertainty	High	Lower	Low	Low	Low
Customising	Complete	Complete	Moderate	Moderate	Varies
Technical skill required of user	Extremely High	High	Moderate	Moderate	Quite Low
Use of existing resources	High	High	Moderate	Low	Very Low

Source: *Adapted from Dangermond and Smith 1980*

Elements of GIS Project Success and Failures

Characteristics of GIS Projects		
Activity	Success	Failure
Planning	Rigorous	'Run and gun' style
Requirements	Focussed	Diffused
Appraisal of effort	Realistic	Unrealistic
Staffing	Dedicated, motivated, high continuity	High turnover
Funding	Adequate	Inadequate, conjectural
Time estimates	Thoughtful	Rushed or prolonged
Expectation	Balanced	Exaggerated

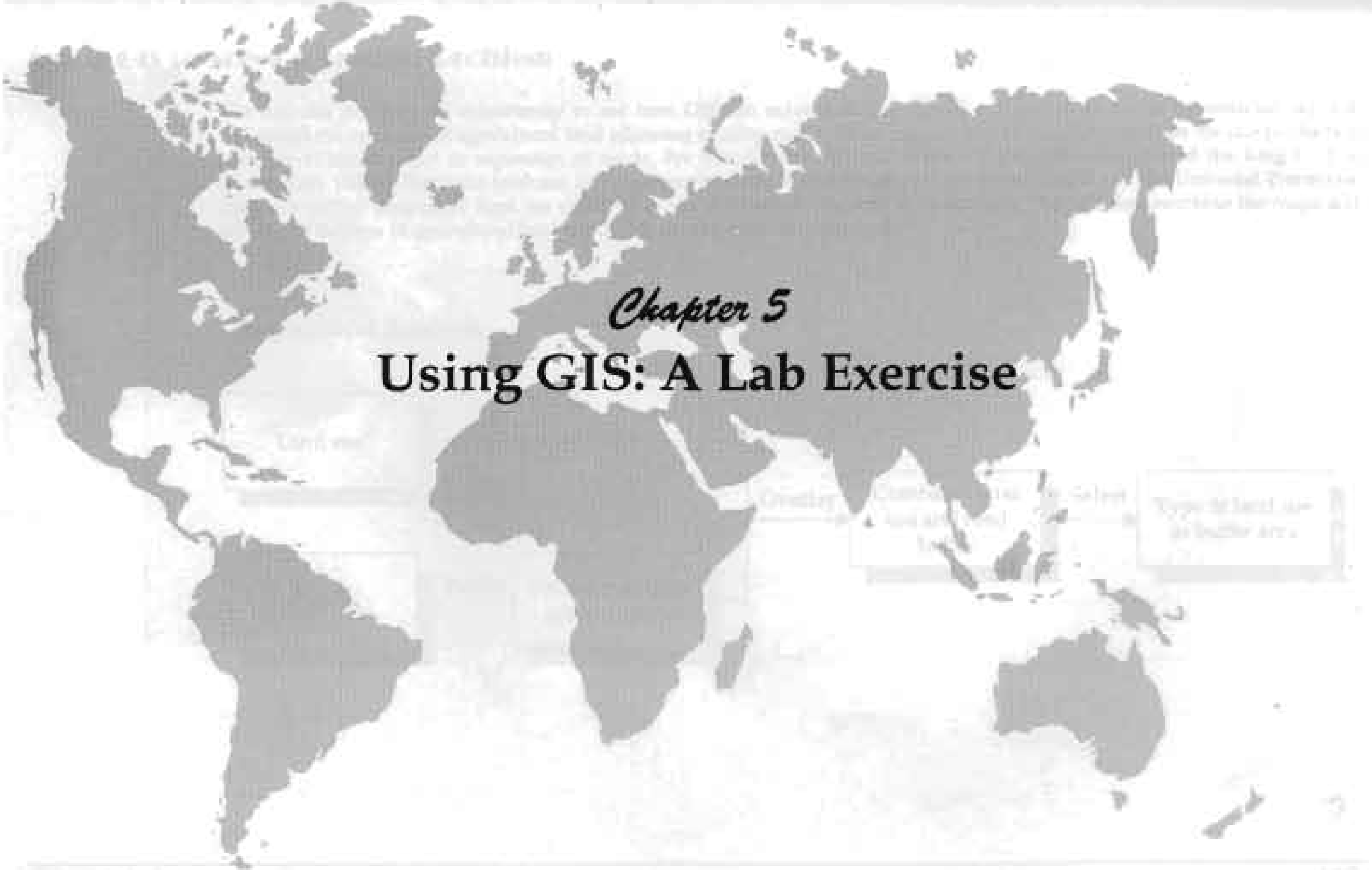
Source:*Antenucci, Brown, Croswell, and Kevany (1991). Copyright 1991 by Chapman & Hall, reprinted by permission*



Strategy/tactics effectiveness matrix. From Schultz, Sleving, and Pinto (1987). Copyright 1987 by Randy L. Schultz, Dennis P. Slevin, and Jeffrey K. Pinto. Reprinted by permission.

Chapter 5

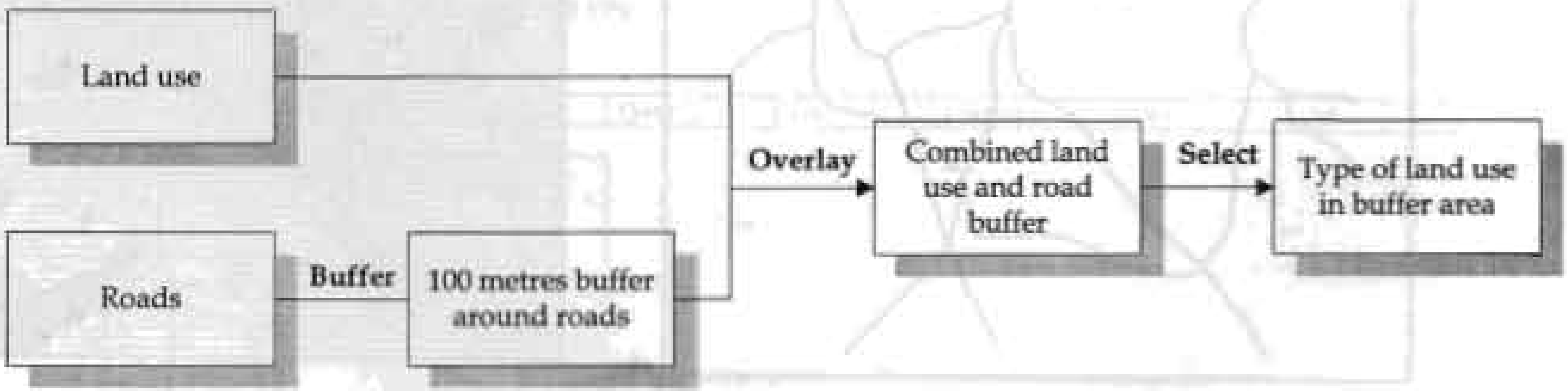
Using GIS: A Lab Exercise



Using GIS to Solve a Spatial Problem

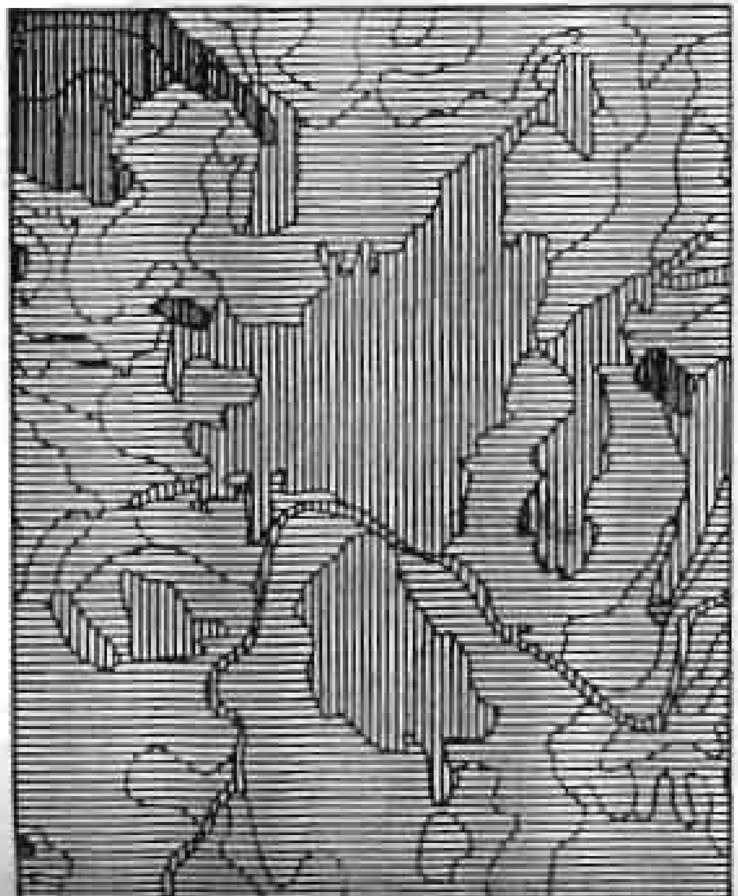
The exercise provides an opportunity to see how GIS can solve a simple spatial analysis problem. In the exercise, we will determine the total area of agricultural land adjoining existing roads. This analysis could be used to determine the rice production lost due to construction or expansion of roads. For this exercise, we will select a rectangular area around the Ring road in Kathmandu Valley. The input land use and road maps, used for analysis, are on a scale of 1:50000 and the Universal Transverse Mercator (UTM) projection. First, we will look at the information on each of these maps. We will then combine the maps and determine the area of agricultural land within 100 metres of the existing roads.

Geographical Analysis

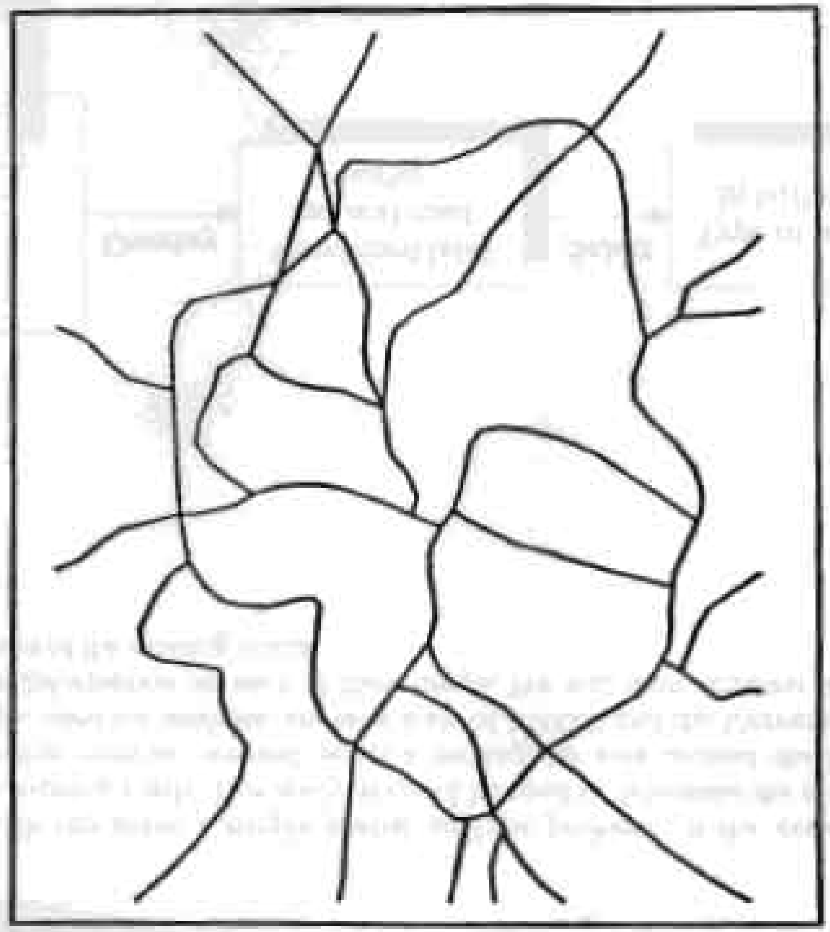


Here is what the maps look like.

Land Use



Roads



Step 1

Start ARC/INFO, and the menu system in the demo workspace

>> C>CD \GISTRN\DATA
>> C. ARC

The [ARC] prompt appears.

Start the menu system and begin this demo:

[ARC] **&RUN INTRO.**

Step 2

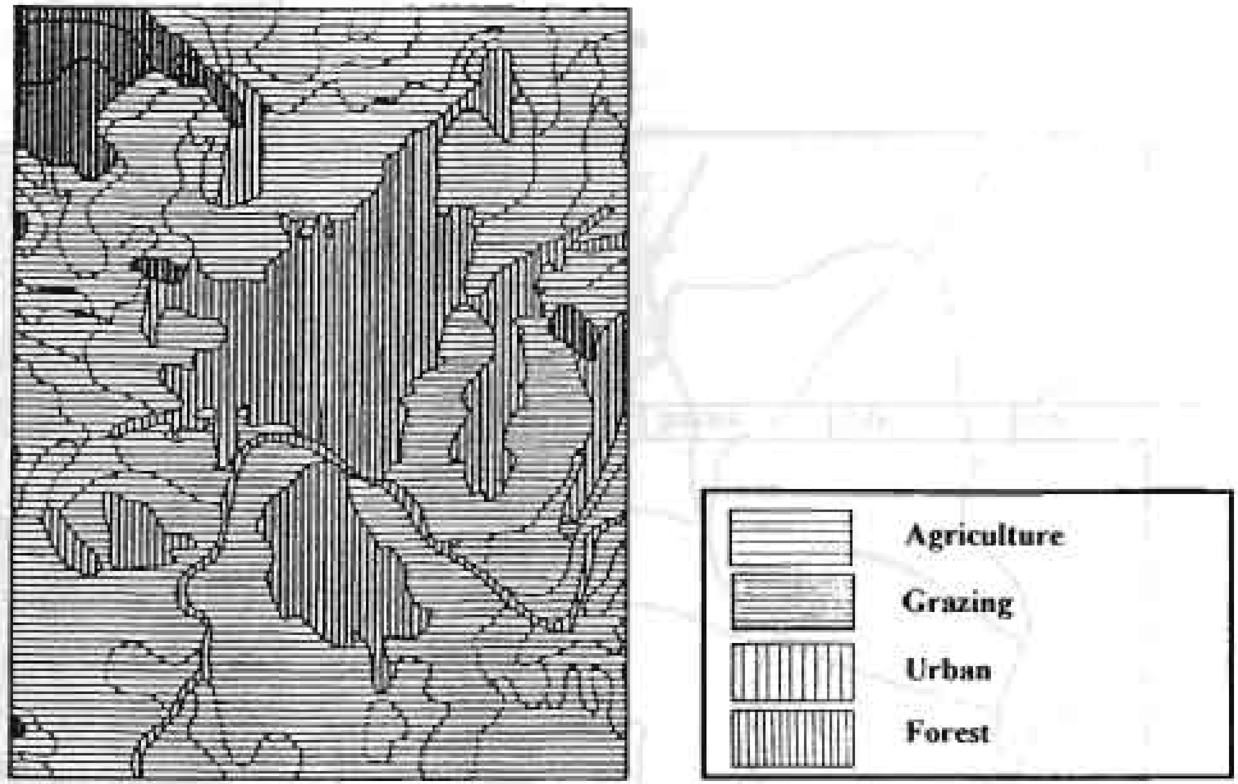
Draw and query the contents of the LANDUSE and ROADS coverages

Choose the **DRAW** option and select **LANDUSE ON**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

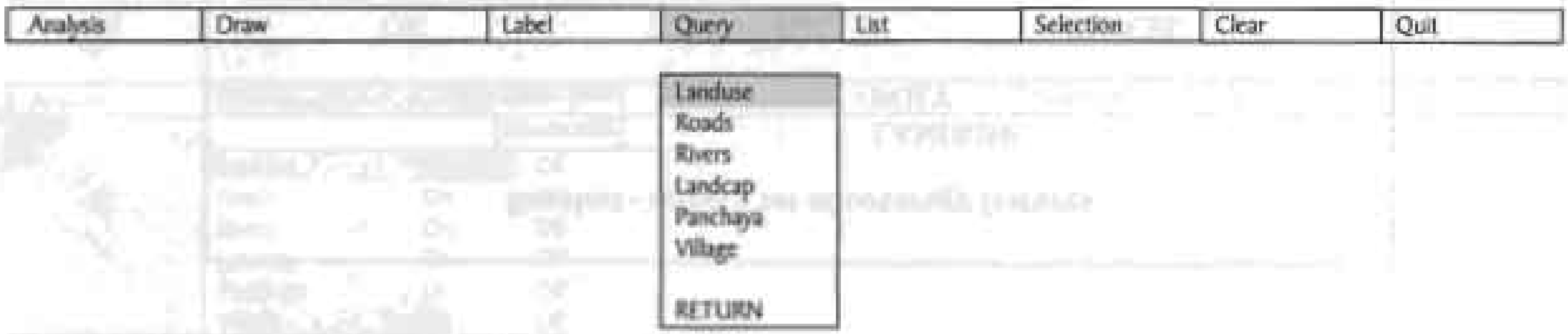
Landuse	On	Off
Roads	On	
Rivers	On	
Landcap	On	
Panchaya	On	
Village	On	
Zoom	On	
PAN	On	
User defined	On	
RETURN		

The display of the LANDUSE coverage will look similar to the figure below:



Each polygon is shaded according to the type of land use. Here is what the shades represent.

Select **QUERY** and choose the **LANDUSE** option



Move the crosshairs over one of the polygons and press the left mouse button or the enter key on the keyboard. The attributes of the polygon are displayed. Move the crosshairs over one of the lines and press the enter key to **quit**.

Here are the codes for all the land use types.

TYPE	LUCODE
Agriculture	2
Grazing	3
Urban	4
Forest	5

To select and draw only the agriculture polygons, first clear the screen.

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Select **CLEAR** from the menu to erase the screen.

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Choose features
Switch features
Clear features

RETURN

Choose **SELECTION**, then Choose features.

Reselect - select a set of coverage features

[coverage] : **LANDUSE**
[feature class] : **POLY**

OK MENU CANCEL

Now in the next menu that appears, enter LUCODE =2. Press <ENTER> to start the selection process.

LANDUSE polys: 53 of 71 selected.

Now the agriculture polygons are selected. To draw them, select the **DRAW** option and then choose **LANDUSE ON.**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Landuse	On	Off
Roads	On	Off
Rivers	On	Off
Landcap	On	Off
Panchaya	On	Off
Village	On	Off
Zoom:	In	
	Study Area	
	Coverage	
PAN		
User defined		
RETURN		

Only the agriculture polygons are drawn.

Now draw the roads.

Choose **DRAW** again, and then **ROADS ON**
The display of agricultural land areas and the roads will look similar to the figure below.

Before proceeding to the next step, select **CLEAR** to clear the display.

Step 3

Create a 100-metre buffer area around the roads.

Select **ANALYSIS** and choose **BUFFER.**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Buffer
Overlay: Union
Intersect
Identify
Statistics
RETURN

Reselect - create constant width buffers

[input coverage] : **ROADS**
[feature class] : **ROADBUF**
[buffer distance] : **100**
[buffer feature] : **LINE**

OK MENU CANCEL

After you've filled out the form correctly, press the **OK** button.

When the buffer is finished, the main menu appears.

Now display the buffer area.

To draw buffer around roads,
select **USER DEFINED** from the **DRAW** column.

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Landuse	On	Off
Roads	On	Off
Rivers	On	Off
Landcap	On	Off
Panchaya	On	Off
Village	On	Off
Zoom:	In	
	Study Area	
	Coverage	
PAN		
User defined		
RETURN		

Fill in the form below to draw the outline of the buffer area polygon.

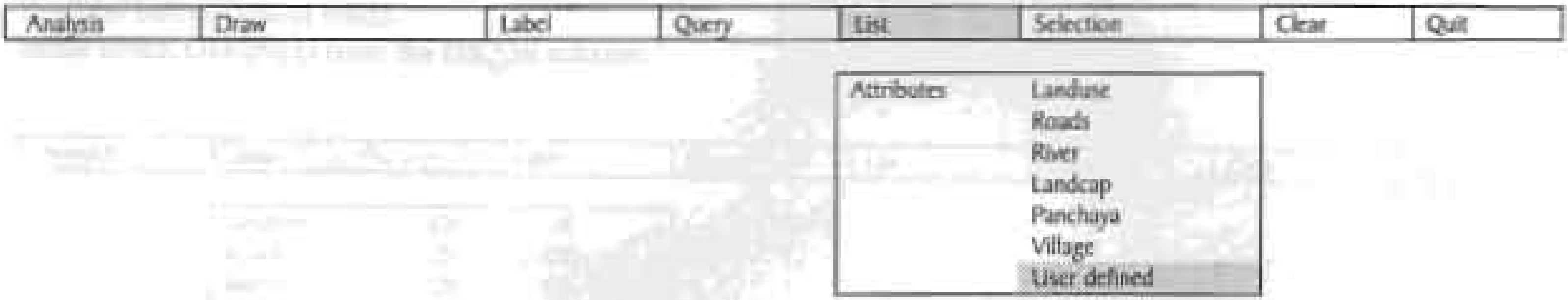
Draw a user specified coverage with a specified symbol

<coverage>	:	**ROADBUF**
[symbol]	:	**1**
<feature to draw>	:	**OUTLINES**

OK MENU CANCEL

Press the **OK** button.

To view the attributes for the buffer polygons, choose **LIST** and then **USER DEFINED.**



Fill in the form below with the coverage name as ROADBUF and feature class as POLY to display the attributes.

Display item values for the specified coverage		
[coverage]	:	**ROABUF**
[feature class]	:	**POLY**
(item)	:	
(item)	:	
OK	MENU	CANCEL

Press the **OK** button to view the attributes.

$RECNO	AREA	PERIMETER	ROADBUF	ROADBUF_ID	INSIDE
1	-.5359674E+08	88988.1600	1	0	1
2	18316940.0000	177013.9000	2	1	100
3	3663801.0000	10565.6300	3	2	1
4	9629993.0000	16837.9600	4	3	1
5	154748.6000	2216.9650	5	4	1
6	1743105.0000	5567.6010	6	5	1
7	1284580.0000	7813.0810	7	6	1
8	2800595.0000	7482.5050	8	7	1
9	3304787.0000	7689.3590	9	8	1
10	5213054.0000	10844.6300	10	9	1
11	5545882.0000	4963.2200	11	10	1
12	694351.2000	5280.3910	12	11	1
13	1244905.0000	4714.3490	13	12	1

Press the <ENTER> key or click the mouse.
Before proceeding to the next step,

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

select **CLEAR** to clear the display.

Step 4

Overlay LANDUSE and ROADBUF using the UNION command and display the results

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Buffer	
Overlay:	Union
	Intersect
	Identify
Statistics	
RETURN	

Select **ANALYSIS** from the menu, then select **OVERLAY**: Union

Fill in the form below to create composite coverage LANDBUF from the two input coverages LANDUSE AND ROADBUF.

Union - spatially join two polygon coverages using union operation		
[input coverage]	:	**LANDUSE**
[union coverage]	:	**ROADBUF**
[output coverage]	:	**LANDBUF**
OK	MENU	CANCEL

Press the OK button to execute the form.

When the menu reappears, the UNION is complete and the new LANDBUF coverage has been created. To display the results of the Union operation, first draw the LANDUSE coverage.

Select **DRAW** and **LANDUSE ON.**

Highlight the area of interest, using a solid shade pattern, and 'white out' those areas outside the 100-metre road buffer. To do this, select those polygons that lie outside the buffer (all polygons that have a value of 1 for the item INSIDE).

Choose **SELECTION**, then **CHOOSE FEATURES**.

Fill in the form as shown.
Press the **OK** button.

Reselect select a set of coverage features		
[coverage]	:	LANDBUF
[feature class]	:	POLY
OK	MENU	CANCEL

In the next menu that appears, enter the selection criterion.

Logical expression

INSIDE = 1

Press the <ENTER> key to start the selection process. A message appears:

LANDBUF polys 170 of 275 selected.

Now, shade these polygons.

Fill in the form as shown.

Draw a user-specified coverage with a specified symbol		
[coverage]	:	**LANDBUF**
[symbol]	:	**1**
[feature to draw]	:	**SHADES**
OK	MENU	CANCEL

Press the **OK** button to shade the polygons outside the buffer.

You can clearly see all the land-use types within the 100-metre buffer. Now highlight the buffer by drawing the ROADBUF coverage.

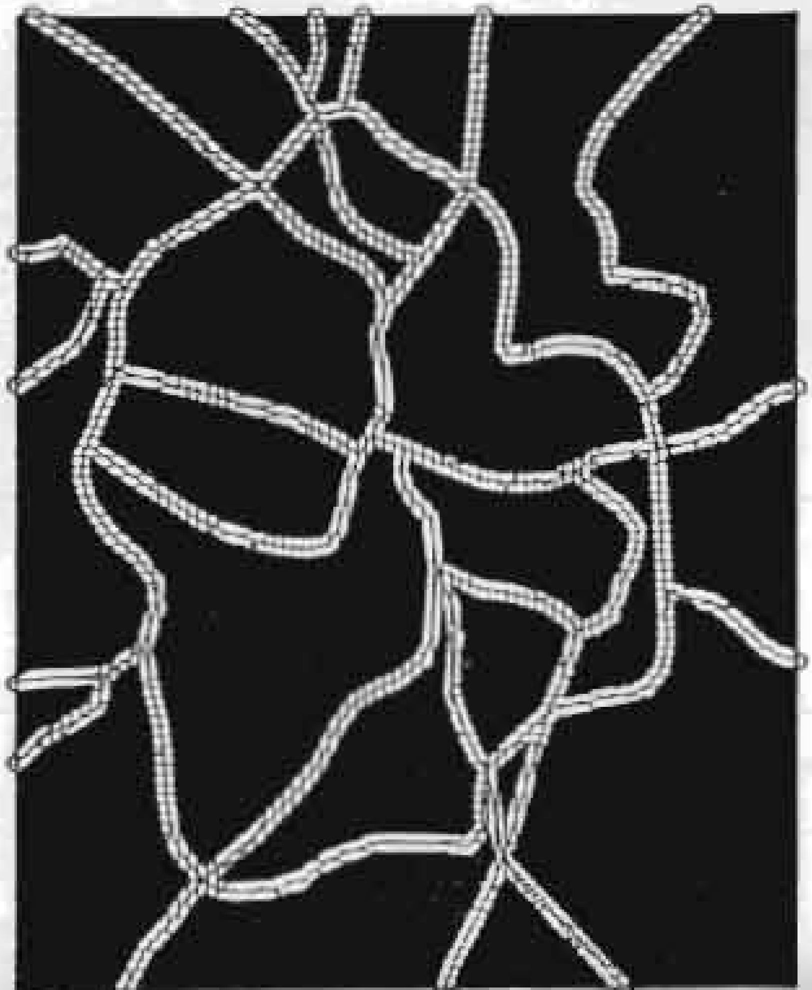
Select **Draw,** then choose **User defined.**
Fill in the form as shown.

Draw a user-specified coverage with a specified symbol		
[coverage]	:	**ROADBUF**
[symbol]	:	**2**
[feature to draw]	:	**OUTLINES**
OK	MENU	CANCEL

Press the **OK** button to draw the road buffer. Finally, draw the road network.

Select **Draw**, then choose **Roads on.**

The display should look similar to the figure below.



Select **List**, then choose **User defined**.

Fill in the form as shown.

Display - item values for the specified coverage

[coverage]	:	**LANDBUF**
[feature class]	:	**POLY**
(item)	:	
(item)	:	
(item)	:	

OK MENU CANCEL

Press the **OK** button.

Notice how the polygons have attributes from both the LANDUSE and the ROADBUF coverages, including LUCODE and INSIDE, respectively. Next, find the total area of agricultural land within 100 metres of the roads.

Step 5 *Generate statistics for the analysis*

Select those polygons that are inside the buffer.

Choose **Selection**, then **Switch features.**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

- Choose features
- Switch features
- Clear features
- Save Selection
- RETURN

Fill in the form menu as shown.

Nselect - switch the select set of coverage features

[coverage]	:	**LANDBUF**
[feature class]	:	**POLY**

OK MENU CANCEL

Press the **OK** button to switch the selected set of polygons.

LANDBUF polys: 105 of 275 selected.

Only polygons with the buffer are selected. Save these selected features on a file on which statistical analysis is to be performed.

Choose **SELECTION**, then **SAVE SELECTIONS.**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Choose features
Switch features
Save Selection
Clear selections
RETURN

Fill in the form menu as shown.

Infofile - save the selected set of coverage features

<coverage>	:	**LANDBUF**
[feature class]	:	**POLY**
[info_file]	:	**LANDBUF.FRQ**

OK MENU CANCEL

Press the OK button.

Now, calculate the total area of each land use type within the 100-metre road buffer.

Select **ANALYSIS**, then choose **STATISTICS**.

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Buffer	
Overlay:	Union
	Intersect
	Identify
Statistics	
Measure	
RETURN	

Fill in the form menu as shown.

Frequency - compute summary statistics for coverage feature attributes

[input file]	:	**LANDBUF.FRQ**
(item)	:	
(item)	:	
(item)	:	
[summary item]	:	**AREA**

OK MENU CANCEL

Press the OK button to execute the form.

Now, calculate the total rice production lost within the 100-metre road buffer.

Select **Analysis,** then choose **Statistics.**

Analysis	Draw	Label	Query	List	Selection	Clear	Quit

Buffer	
Overlay:	Union
	Intersect
	Identify
Statistics	
Measure	
RETURN	

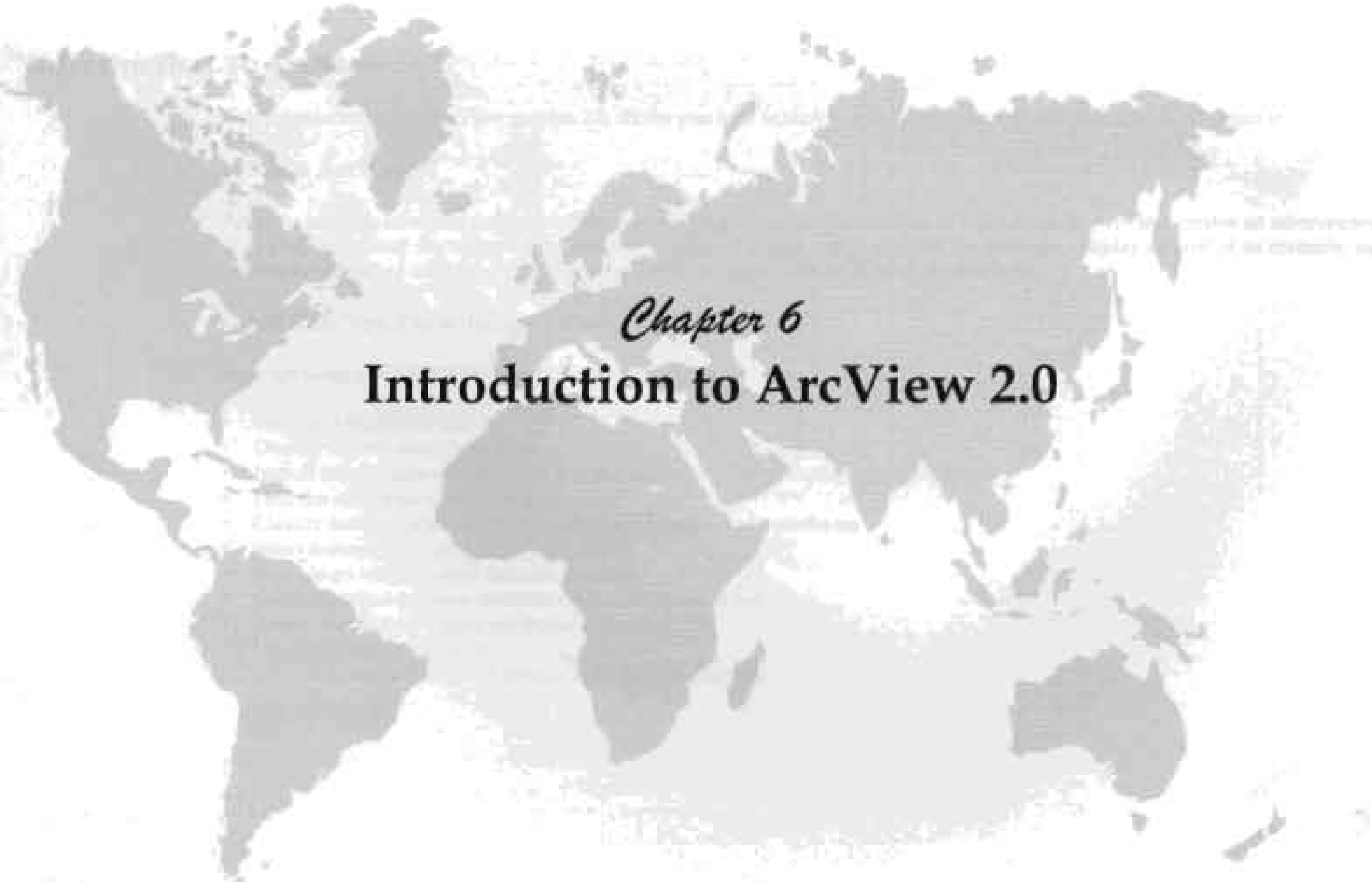
Fill in the form menu as shown.

Frequency - compute summary statistics for coverage feature attributes

[input file]	:	LANDBUF.FRQ
(item)	:	
(item)	:	
(item)	:	
[summary item]	:	PRODUCE

OK MENU CANCEL

Press the **OK** button to execute the form.



Chapter 6

Introduction to ArcView 2.0

Introduction To ArcView

This introduces you to ArcView version 2.0, shows you how to start it, and directs you to on-line sources of information.

What is ArcView ?

ArcView is a powerful and easy-to-use tool that brings geographic information to your desktop. ArcView creates an environment to display and query the contents of a spatial database. It allows you to explore the database, display all part of its contents, ask questions, display or save results, and pass information or graphics on to other applications.

What Can You Do with ArcView ?

Here are some of the key tasks you can accomplish with ArcView.

- Display ARC/INFO Data
- Display tabular data on a view
- Import tabular data and then join it to the data in a view to display it geographically
- Find the attributes of any features
- Classify features with different symbols according to their attributes
- Select features according to their attributes
- Find places where certain features coincide
- Summarise and generate statistics on the attributes of features
- Create charts showing the attributes of features
- Lay out a map and print it
- Lay out a map and export it for use in another application

Chapter 1

Projects and Views: Managing Your Work and Displaying and Querying Spatial Data

What is a Project ?

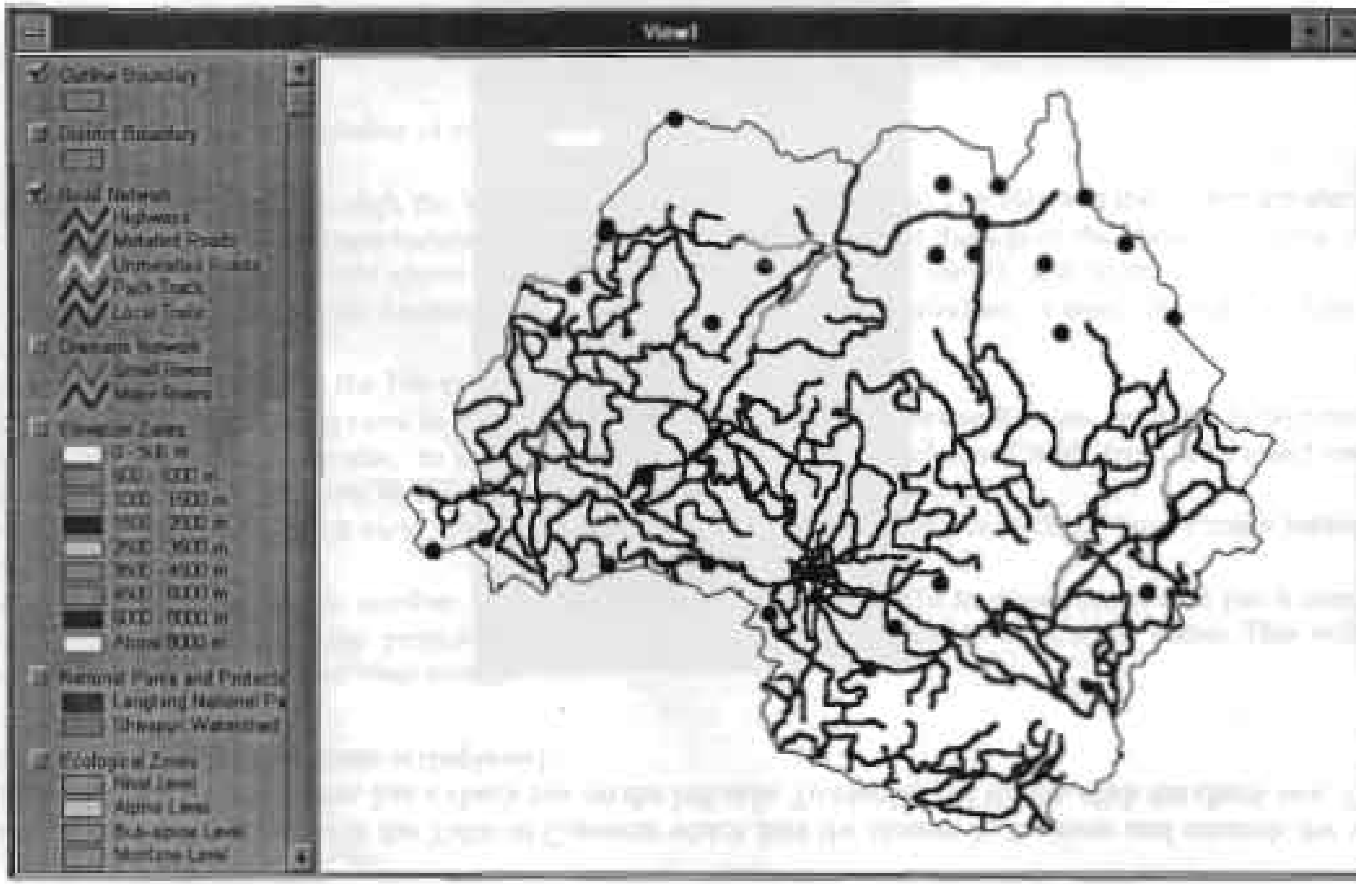
All the components of your ArcView session - views, tables, charts, layouts, and scripts - are conveniently stored in one file called a project. The project file shows you the contents of your project and makes it easy to manage all your work. Project files have the .APR extension.

When you open a project file, the components in the project are listed in the Project window. From the Project window, you can add or remove components from your project and give a component a descriptive name.

What is a View ?

A view is an interactive map that lets you display, explore, query, and analyse geographic data in ArcView. A view defines the geographic data you use and how to display it, but it does not contain the geographic data files themselves.

A view is actually a collection of themes. A theme represents a distinct set of geographic features in a particular geographic data source.



What is a theme ?

A theme is a set of geographic features in a view. A theme represents one of the following sources of geographic data:

- an spatial data source, such as an ARC/INFO coverage,
- an image data source, such as a satellite photo, and
- a tabular data source containing events, such as a table with X, Y coordinates.

The themes in a view are listed in its Table of Contents. For example, a view of a city might have one theme representing major highways, metalled roads, non-metalled roads, and one theme representing the drainage network of an area, etc.

Each theme has its own legend displayed in the Table of Contents. A theme's legend controls how the theme is displayed on the view. You can edit the colours and symbols of a theme.

Table of Contents

On the left side of the view's window is the Table of Contents which lists the themes in the view and controls the visibility of the themes and drawing order. Each theme, has a check box on the left side. To display the theme, click the check box. The check mark ✓appears in the check box and the theme is displayed.

When you are working with a view, you will see the view's menus, buttons, and tools.

Working with Views in a Project

An ArcView project can contain any number of views.

- To see which views are in a project, click the Views button in the project window. The views in the project are shown in the list.
- To create a new view, with the **Views** button selected, click the New button at the top of the project window. A new empty view will appear. ArcView names new views in numerical order: View1, View2, View3, and so on.
- To open a view, double click the view's name in the list of views in the Project window, or select the view's name and click the Open button.
- To close a view, choose Close from the File menu.
- To rename a view, click once on the view in the list in the Project window and choose Rename from the Project menu.
- To delete a view: click once on the view in the list in the Project window and choose Delete from the Project menu. To select several views for deletion, hold down SHIFT and click the other views to delete.
- To save the work undertaken with a view, choose Save Project from the File menu or click the Save Project button in the View button bar.
- To copy a view from one project to another, if you want to get a view that is in another project and put it into your current project, you should import the other project into your current one using Import in the Project menu. This will copy all the components of the other project into your project.

Exercise 1

There should be an existing database for ArcView to work. For this lab exercise, you will use the Bagmati datasets on a scale of 1:250,000. The available ARC/INFO datasets of Bagmati Zone that you can practise with and incorporate into your projects are: Outline, District Boundary, Elevation, Ecological Regions, Roads, River, National Parks and Protected Areas, Settlements, and Spot Heights.

In this exercise, you will learn the following.

- How to create a project
- How to create themes
- How to edit a theme's legend
- How to classify spatial data
- How to move around the display
- How to carry out spatial analysis
- How to select features
- How to carry out logical selection
- How to define themes
- How to edit a theme

Getting Started

Click the ArcView icon to start ArcView from the Microsoft Office Window.

Creating a Project

When you create a project, you create one file that contains the views, tables, charts, layouts, and scripts that make up the project.

To create a project, choose **New Project** from the **File** menu.

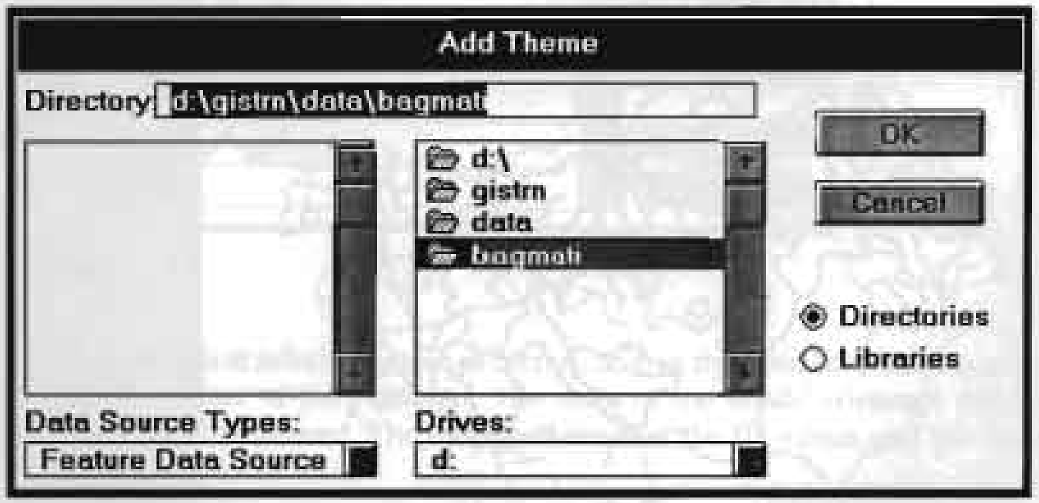
ArcView creates a new project called Untitled and opens the Project window.

Creating a Theme

You can create a theme, selecting the data source that you want it to represent. Any supported data that you have read access to can be created in a view as a theme.

To create a theme of ARC/INFO coverages of the Bagmati dataset -

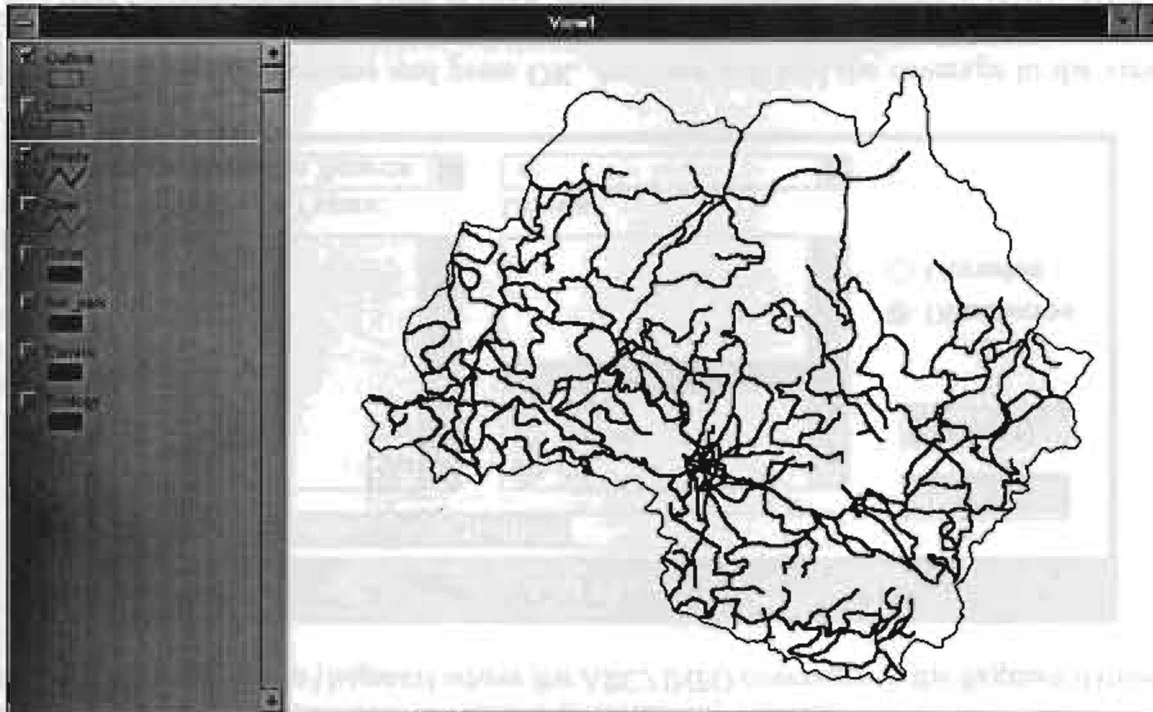
- From the **View** menu choose **Add Theme** or click the **Add Theme** button to display the Add Theme dialog box.
- In the *Data Source Types* box, choose *Feature Data Source* if it is not already selected.
- Navigate to the directory *d:\gistrn\data\bagmati* where the ARC/INFO coverages of the Bagmati dataset are contained.



- Now double-click all the features one-by-one and press **OK**. ArcView will add the coverage to the view's Table of Contents and choose the feature class for you.
- To add all the ARC/INFO coverages into a view at once, select the coverages by holding down **SHIFT** and clicking on the coverage, and then press OK.

When you create a theme, ArcView does not immediately draw it on the view. This enables you to first edit the theme's legend or change the drawing order. To draw the added theme, click on the check box next to the theme's name in the view's Table of Contents.

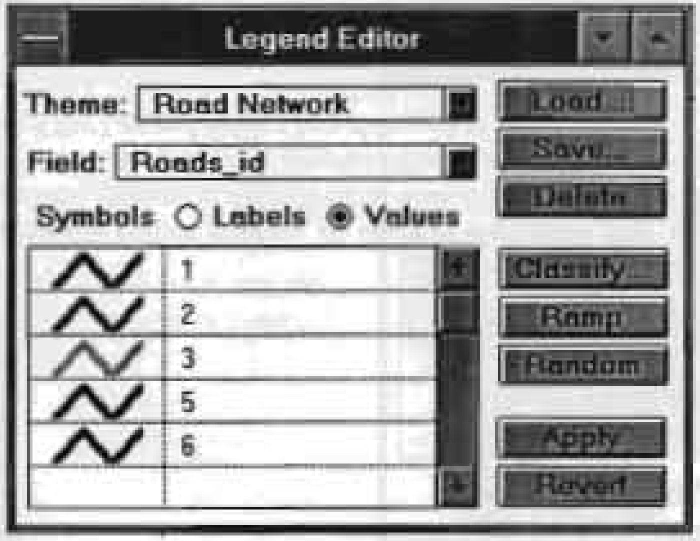
Now, to draw the roads of Bagmati, click on the Roads' theme. The roads will be displayed in a view. You will notice that all the roads are displayed in one colour, which indicates they are the same type of road. However, they are not. Five different types of road are defined in this coverage. So, to display five different types of road in a view, you need to edit the legend of the theme Roads.



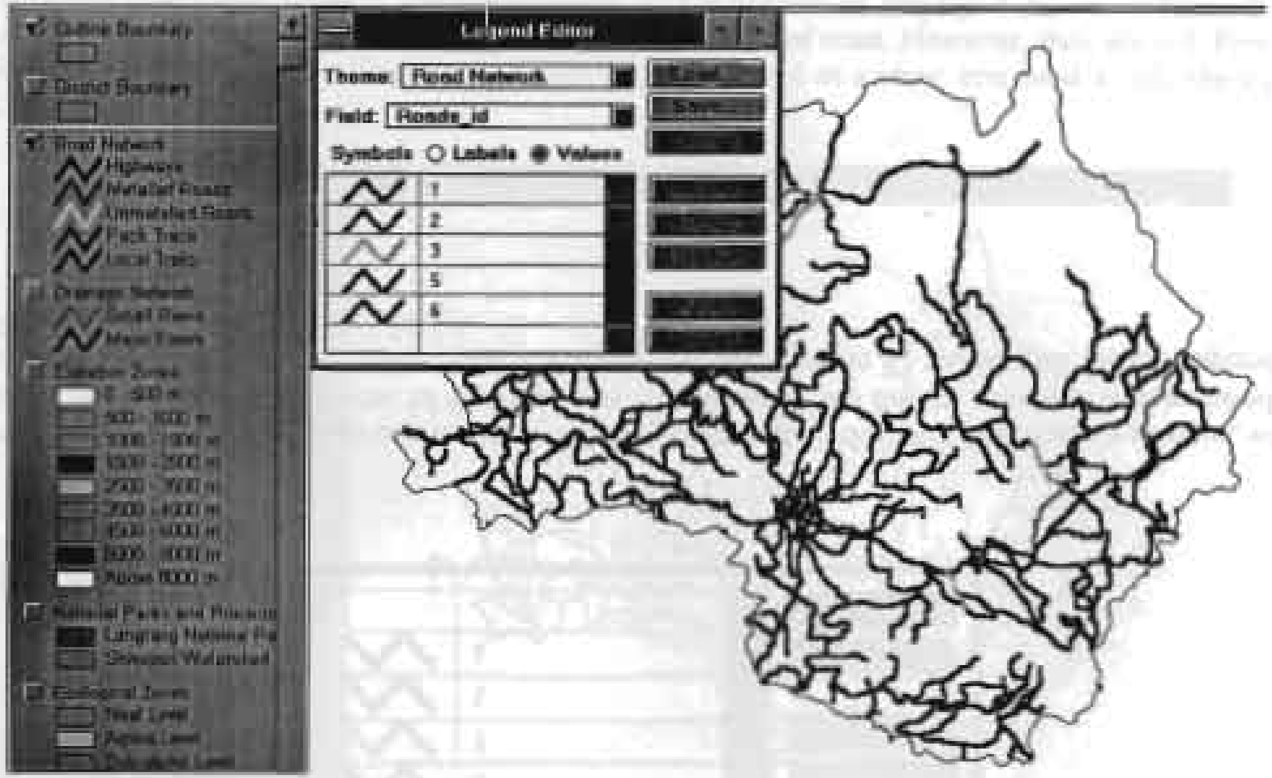
Editing a Theme's Legend

By editing a theme's legend with the Legend Editor you can change the patterns and colours of the symbols that ArcView uses to draw the theme in your view.

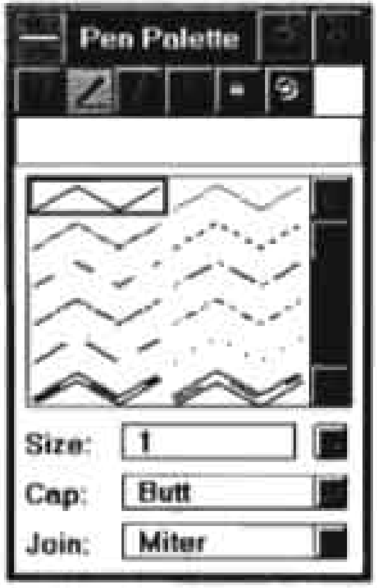
To edit the legend of Roads, first click once on the theme Roads in the Table of Contents to make it active. Then choose Edit Legend from the Theme menu or double-click the theme Roads. ArcView will display the Legend Editor.

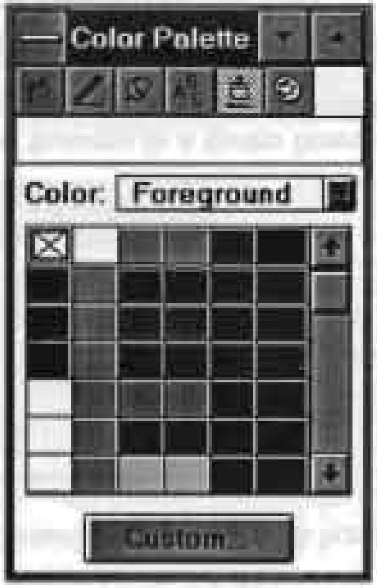


In the Theme box, you will notice that Roads is selected, which is correct, and, in the Field box, None is selected, which you have to change. Click the 7 button in the right corner of the Field box. The items of the Roads' coverage will be listed. Select the item ROADS_ID according to which roads are categorised. Then you will see that the ID values and the corresponding symbols are displayed. Edit the ID values accordingly to 1,2,3,5,6.



Now, change the colour of the lines using the colour palette. To display the roads with the ID value 1 in red, double-click on a symbol in the Legend Editor. The pen palette (figure) is displayed in which you can define the thickness of the line. To change the colour, click once on the colour button. The colour palette is displayed, choose red. As soon as you choose red, you will notice that the colour of the line in the symbol field of the Legend Editor has changed to red.

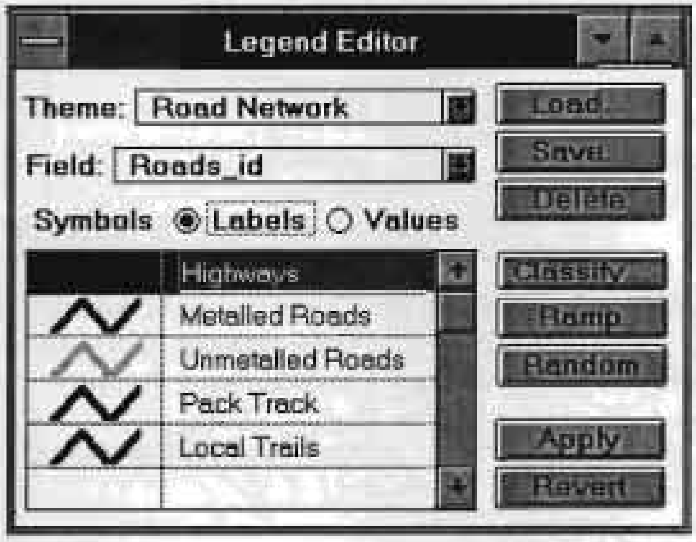




Similary, change the colour of the other individual lines as you desire.

After choosing the colours, the next step is adding labels. You can enter your own text label next to each symbol in the theme's legend in the Table of Contents. This allows you to describe what each symbol represents. Press the Labels' button on the Legend Editor and enter the text you want to appear next to each symbol. Add the text for each type of road as follows.

ID Value	Type of Roads
1	Highways
2	Metalled Roads
3	Non-metalled Roads
4	Pack Track
5	Local Trails



Press Apply and your labels and colours will appear in the Table of Contents. Click the check box to display your results in a view.

Hiding a Theme's Legend

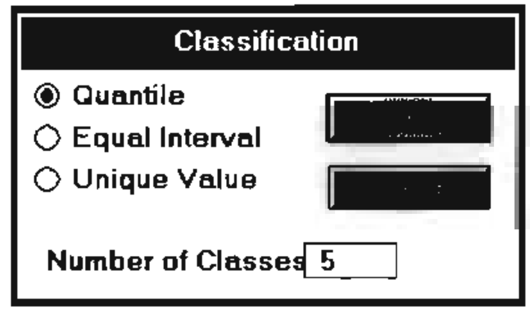
The legend of each theme in a view is normally shown in the view's Table of Contents. However, You can save space in the Table of Contents by hiding legends. To hide a theme's legend, click on the legend to make the theme active, and then choose Hide/Show Legend from the Theme menu.

Classifying Spatial Data

By specifying a range of symbols, you can symbolise and classify the features in a theme based on the values they have for any field in the theme's attribute table. You can change the classification and symbols of a theme with the Legend Editor.

To classify the features, the procedure is as follows.

- In the Legend Editor, choose the name of the field you wish to use to symbolise the theme.
- Set the number of classes or type of classification you require by pressing the Classify button to set the classification to either Quantile, Equal Interval, or Unique Value.



To choose a random range of colours, the procedure is as follows.

- Press the Random button in the Legend Editor.

Up to now, you have created a theme for the Roads' coverage. Similarly, create themes and edit the legends of other coverages.

Move Around the Display

- You can use the view button bar and tool bar to move around and zoom in on the display.

- Use this  button to zoom to the full extent of all the themes in a view which allows you to see everything.
- Click on a theme in a view's Table of Contents to make it active, and then click this button  to zoom to the area covered by the active theme.
- When you have selected the features on a view, click this button  to zoom to these features of the active themes of the view.
- Use this button  to zoom in on the centre of a view.

- Use this button to zoom out from the centre of a view.
- Use this button to zoom in on the position you click.
- Use this button to zoom out from the position you click.
- Use this button to pan the view by dragging it in any direction at any time.

Performing Spatial Analysis

Spatial analysis operations provide the means to look for or determine relationships between themes, to assign the attributes of another, and to perform aggregation of both features and attributes.

Spatial analysis operations available in ArcView include the following.

- Finding point features that are nearest to the selected point or line features
- Finding point features according to the polygon features they fall inside (point-in-polygon)
- Finding line features according to the polygon features they cross (intersection).
- Finding polygon features according to the polygon features with which they coincide (intersection; polygon-in-polygon)
- Finding features that are adjacent to the selected features
- Creating new features by merging a set of adjacent features into one single feature or aggregate disjunct features
- Selecting features by specifying a buffer distance

Selects the features of the active themes with the features of the theme you specify. Choose Select By Theme in the Theme menu.

To select a theme using another theme, follow this procedure.

1. Make the themes to be selected active. These are the target themes.
2. In the Theme menu, choose Select by Theme.
3. Choose the spatial relation type.

   This phrase qualifies the selection. ArcView provides several spatial relation types. The types you see depend on the selector theme's feature type. In some cases, you may want to pick the selector theme before choosing the spatial relation type.

4. Pick the theme from which the features are used to make the selection.

This is the selector theme. ArcView selects features in the target themes using the selected features of the selector theme. If no features in the selector theme are selected, ArcView uses all the selector theme's features to select.

5. If you choose Are Within Distance of, specify the selection distance.

   ArcView selects the features in the target themes whose distance to any of the features in the selector theme is less than or equal to the selection distance. The selection distance units are the distance units of the view. Set the distance units in the View Properties dialog box.

6. Choose a selection method.

   ArcView provides three selection methods. New Set creates a new set of selected features from all candidate features. Add to Set adds new features to the existing selected set of features. Select from Set selects features only from candidates in the currently selected set of features.

Notes

- Specifying a selection distance essentially creates a buffer polygon around the features of the selector theme; however, the buffer polygon is not visible.
- If you specify a selection distance of 0, ArcView selects the features that intersect the selector theme's features. A selection distance of 0 selects all points in the target themes that fall within a polygon, all lines that intersect, and all lines that intersect the selector theme's polygons and all polygons that intersect the selector theme's lines.
- ArcView uses the selected features of a theme to make the selection; therefore, if the active theme is the same theme as the selector theme, and you choose Intersect, you can select features that are adjacent to the selected features.

Example

To identify the Settlements that are within 1,000 Metres of the Roads

1. In this example, you are dealing with the distance. So, your first task is to set the map and distance units. To do this, choose Properties from the View menu. Set the map units and distance units to metres and press OK.
2. Activate the Settlement in the view's Table of Contents by clicking once, if it is not already activated.
3. Click the check box to display the settlements and roads.
4. Select Select by Theme from the Theme menu.
5. In the *Select features of active themes* box, select Are within Distance of.
6. In the *Selected features of* box, select Roads.
7. Select New set to exit from the Select by Theme menu and wait for a few seconds. ArcView will display the settlements within 1,000 metres of the roads in different colours (yellow).

You can check your results by measuring the distance of marked and unmarked settlement points from roads. To do this,

1. click the measurement button,
2. select any yellow marked settlement point by clicking once, and
3. stretch the measurement cursor to the roads around it.

The distances will be displayed on the lower left hand corner of the screen. Similarly, check for other points.

Selecting Features

Selecting features on a view enables you to:

- find specific geographic features that interest you or meet certain important criteria, and
- work with specific geographic features in a variety of ways to find out more about them.

There are several ways to select features on a view. You can select them according to their location, according to their attribute values, or by selecting their records from a table. You can select features from one or more themes. Before you can select features from a theme, you have to click on the theme in the Table of Contents to make it active.

Features highlights views when they are selected and they remain highlighted until a different selection is made, or until they are deselected.

<u>Selecting Features with the Mouse</u>

The Select Feature tool allows you to select features with the mouse by pointing at them or by dragging a selection box over them. Features that fall partly or wholly inside the box you define will be selected.

<u>Selecting Features Using Shapes</u>

Shapes, such as circles, boxes, lines, and polygons, drawn on a view using the Draw tool can be used to select features. Simply draw the shape and then press the Select Features Using Shape button.

<u>Selecting a Feature Using Find</u>

Find is a quick way to select a particular feature of interest. For example, if you are working with a theme of the settlements and you want to select *Koteswor*, simply type the name into the Find dialog box.

<u>Selecting Features Using a Query</u>

Use a query when you want to select features according to their attribute values. For example, you can build a query to select all the settlements in Bagmati Zone with populations of more than 10,000. You can also build more complex queries.

You can also use the Query Builder to narrow down your selection by building a query that only selects features from the set you have already selected.

Example

You Have a Theme Displaying the Point Locations of Settlements, and Want to Find Out the Settlements within a 10,000 Metre Radius of *Kathmandu Municipality*

In this case, you do the following.

1. Click on the settlement theme in the Table of Contents to make it active.
2. Use the *Draw tool* to draw a circle with a 10,000 metre radius centered on the Kathmandu Municipality location.
3. Choose the Select Features using the Shape button to select the settlements in this area.
4. Click the Query Builder button. ArcView displays the Query Builder. Build a query to select the settlements having a population greater than 10,000.
5. Press the Select From Set button on the Query Builder. From the set of settlements that is already selected, ArcView will select those that match the query.

Selecting Features by Selecting Records in a Table

A theme's attribute table contains one record for each feature in the theme. When you open a theme's attribute table containing the attributes of a theme's features, selecting records in the table automatically selects the features they represent on the view.

To select features by clicking on records in the theme's attribute table

1. Click on the theme in the Table of Contents to make it active, if it is not already.
2. From the Theme menu choose Table or click the Open Theme Table button. ArcView displays the theme's attribute table.
3. Hold down SHIFT and click on the records you want to select. The features in the theme represented by these records are also selected in the view (You can also use the keyboard to select records in the theme's attribute table.)

Selecting Features Using a Chart

A chart created from a theme's attribute table contains one data marker for each selected feature in the view. By erasing data markers in the chart, you can deselect features on the view. In this way, you can use the chart to focus on particular features of interest.

Logical Selection: The Query Builder

The Query Builder allows you to select features on a view and records in a table by defining a query based on their attribute values.

Building a Query

To build a query, choose a Field, then an Operator, and then a Value. You build a query by double-clicking on these options with the mouse or by typing your query directly into the query text box. By default, the query is contained within parentheses. However, parentheses may not be required, depending on the complexity of your query. If the Update Values choice is on, click once on a field name to list its values in the Values' list. Field names are always enclosed in square brackets ([ ]). If the value you want to use in the query is not in the Values' list, type it into the query text box.

Example

1. To select elevation zones between the range of 1,500 - 2,500 metres, you can use the query (Note: Item GRID_CODE represents the elevation value).
   ([GRID_CODE] >= 1500) and ([GRID_CODE] <= 2500)

   To do this:

   a. click the theme RELIEF to activate it,
   b. select the Query Builder button (fig) OR select Query from the Theme menu,
   c. to build the query, choose the field (GRID_CODE), then an operator (>=), then a value (1500), again an operator (and), then the field (GRID_CODE), then an operator (<=), then a value (2500), and
   d. select New Set.

   ArcView will display the zones that match the criteria.

2. Strings, such as names, are always quoted in queries. Strings are case insensitive, so you can select the VDC *Bidur* with:
   ([VDCNAME] = "BIDUR")

3. Use * as a multiple character wildcard. For example, to select *Ramche* you could use the query:
   ([VDCNAME] = "RAM*")

4. Use ? in a string as a single character wildcard. For example, to find Salyankot and Methinkot, use:
   ([VDCNAME] = "??????kot")
5. To select all the VDCs with names starting with the letters D, you could use:
   ([VDCNAME] > "D")

Defining a Feature Selection for a Theme

By default a theme represents all the features of a particular feature class in its data source. However, it is useful to be able to restrict a theme to represent only a subset of the features in a particular feature class.

For example, you might have a data source that contains arcs for all the roads in your study area, but you want to create a theme that only represents the major highways. In this case, you would first add the theme to your view and then edit its theme properties to define a feature selection consisting of the major highways.

By defining a feature selection you can control exactly which features from a theme's data source are represented in the theme. Features are selected based on the attribute values in the theme's attribute table. The feature selection is defined as a query in the Query Builder accessed from the Theme Properties dialog box.

To define a feature selection for a theme:

1. click on the theme in the Table of Contents to make it active,
2. from the Theme menu, choose Properties or click the Theme Properties button - the Theme Properties dialog box will be displayed,
3. choose the Definition category of properties if this has not already been chosen,
4. press the Query Builder button. ArcView displays the Query Builder,
5. build a query,
6. press OK on the Query Builder - your query appears in the Theme Properties definition box, and
7. press OK on the Theme Properties dialog box.

Arc View will select the features that match the query and redraw the view. Only those features that are selected in the query are now in the theme.

Example

The theme NAT_PARK actually represents National Parks. The title itself may not be clear to all. Define the theme NAT_PARK as *National Parks* to make it more clear.

1. Click the theme NAT_PARK to activate it, if not already activated.
2. Select **Properties** from the Theme menu.
3. Type *National Parks* in the Theme **Name** box and press **OK**.

Chapter 2

TABLES: Attributes of Spatial Data

What is a Table ?

A table lets you work with data from various tabular data sources in ArcView. In fact, with ArcView's tables you can access almost any tabular data resource in your organisation and work with it spatially!

- You can display, query, and analyse data in tables. You can highlight records in tables by selecting geographic features displayed on views, and vice versa.
- You can display tables on a view to reveal the geography of your data.
- You can easily create charts from tables to visualise trends, patterns, and distributions.

Working with Tables in ArcView

An ArcView project can contain any number of tables.

To See which Tables Are in a Project

Click on the Tables' icon in the Project window. The tables in the project are shown in the list.

To Open a Table

Double-click the table's name in the list of tables in the Project window, or select the table's name and click the Open button.

To Open a Theme's Attribute Table

1. Open the view containing the theme.
2. Click on the theme to make it active.
3. Choose Table from the Theme menu or click the Open Theme Table button in the View button bar.

When you open a theme's attribute table, it will appear in the list of tables in the Project window. It can also be opened using the Open button on the Project window, as described above.

To Add a Table into a Project

Use Add Table in the Project menu to open a dBASE, INFO, or delimited text file as a table in your project.

You can add an INFO, dBASE III, dBASE IV file, or a tab-delimited or comma-delimited text file to create an ArcView table in the current project.

Adding Tabular Data

To add an INFO, dBASE, or text file:
1. open a project or make the Project window active for the open project,
2. from the Project menu, choose Add Table,
3. in the List Files of Type box, choose INFO, dBASE, or Delimited Text,
4. navigate to the directory that contains the file you want to add, and
5. double-click the file you want to add or choose the file and press OK.

ArcView creates a table named after the file you selected.

Creating a New Table

You may want to create a new table in ArcView and then add data to it.

Create a New Table in Your Project

On the Project window, select the Tables' icon and then press the New button. Enter a name and a disk location for the dBASE file that ArcView will create to store the source data for the table. A new table will appear in your project. ArcView names new tables in numerical order: Table1, Table2, Table3, etc.

Add Fields to the Table

On the Table menu bar, select the Add Field choice from the Edit menu. The Field Definition dialog box will appear allowing you to define the field in the table.

Add Records to the Table

On the Table menu bar, select the Add Record choice from the Edit menu. This will add a single record to the table. Repeat this action as many times as needed.

Add Data to the Table

On the Table tool bar, select the Edit tool. This allows you to edit the empty cells in the table.

Adding and Deleting Records

To Add a Record

In the Edit menu, choose Add Record.
If you add a record, use the Edit tool to update the values for the new record.

To Delete a Record

In the Edit menu, choose Delete Record. You must select one record before this choice becomes active.

Editing Records in a Table

By default, you are not allowed to edit a table. ArcView shows this by displaying the field names in the table in italics.

Only tables based on dBASE or INFO files on disk may be edited. Tables that have been created by connecting them to a database cannot be edited, because ArcView does not commit changes back to database servers. You cannot edit tables created from delimited text files.

If you have the write permission to the data file on which the active table is based, and you wish to edit it, you can choose Start Editing.

If you do not have the write permission to the data file, Start Editing will be unavailable.

All editing, except for deleting fields and records, are immediately written to the source data file. To finish editing (and/or commit deletion editing) use the Stop Editing control.

Calculating Field Values

You can use the Calculate dialog box to calculate the value of the active number, string, date, or boolean field.

The value is the result of an expression that you enter into the text input area of the dialog box. The calculation applies to the selected set of records. If no records are selected, the calculation applies to all records. You can enter the expression by double-clicking on field names and requests or you can type the expression yourself.

In its simplest form, an expression can just be a number, a string, a date, or a boolean value. For example, to set the value of a string field named [Zoning] to the string "Industrial", type the string enclosed in double quotes in the text input area of the dialog box. To set the value of a number field to the number 143, type the number in the text input area of the dialog box.

In addition, an expression may consist of any combination of field names, enclosed in square brackets, and valid Avenue requests that can be made on the class type of the field. The result of the expression must be a single object or value.

Sorting Records

Sorts a table on the active field. Click on a field name in a table to make it active and then choose Sort Ascending or Sort Descending.

Table Menu Bar

Sort Ascending and Sort Descending in the Field menu

Table Button Bar

Ascending Order

Using the active field, this control puts the record with the value at the beginning of the alphabet, the earliest date, or the lowest number, at the top of the table.

Descending Order

Using the active field, this control puts the record with the value at the end of the alphabet, the latest date, or the highest number, at the top of the table.

To Sort a Table

1. Click on the name of the field you wish to sort on to make it active. The name of the field will be highlighted.
2. Choose Sort Ascending or Sort Descending from the Table menu or the Table button bar.

Sorting always occurs on all the records in a table. If you want to sort the selected records, sort the table and then use Promote. Promote will display the selected records at the top of the table, in the order in which they occurred in the sorted table.

When you close a table, close the project that contains it, or export a table. Any reordering of records that you have carried out by sorting or promoting is not saved. The next time you open the table, the records will be in their original order.

Joining Tables

Joining tables enables you to attach your tabular data to the themes in a view so that you can display, identify, query, summarise, and analyse your data spatially.

Examples

You have a dBASE file containing population data for all the districts in Bagmati Zone. To display this data in a view:

1. add the dBASE file into ArcView as a new table,
2. open the attribute table of a theme representing the districts,
3. use the Join control to join the new table to the theme's attribute table, and
4. edit the theme's legend to specify which data will be displayed.

Remove Joins

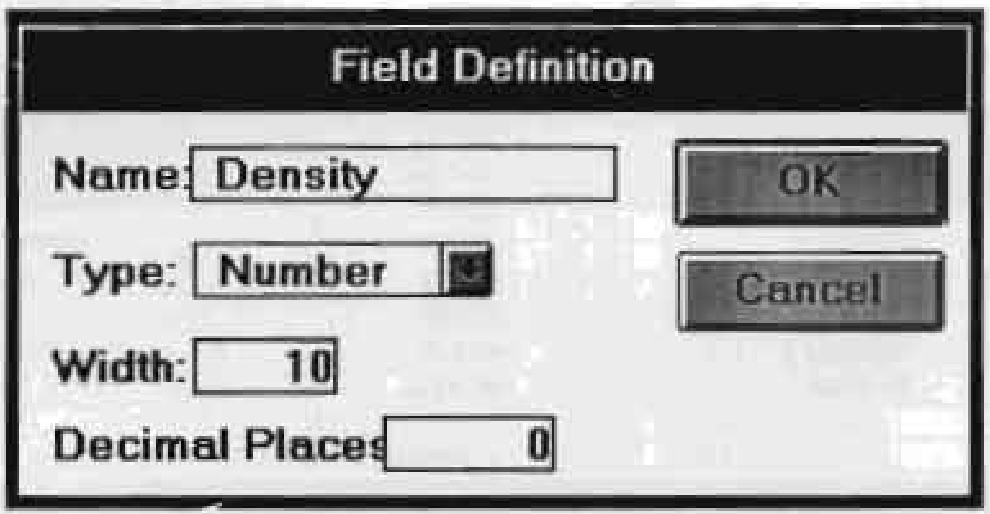
To remove joined fields from a destination table, use Remove All Joins from the Table menu.

In this exercise, you will calculate the population density and population growth rate of each district of Bagmati Zone using the census data from 1981 and 1991.

Add New Fields POP_91, POP_81, DENSITY, GRW_RATE in the Theme District.

For this exercise, your first task is to add the fields representing the population in 1981 and 1991, growth rate, and population density of each district. To do this,

- click on the theme District to make it active, if it is not already active,
- choose Table from the Theme menu or click Open Theme button in the view button bar,
- use Start Editing from the Table menu,
- choose Add Field from the Edit menu,
- type POP_91 in the Name box, select Number in Type box, type 10 in Width box, and type 0 in Decimal Places box, and
- similary, add fields POP_81 (*number, 10, 0*), DENSITY (*number, 6, 2*), and GRW_RATE (*number, 4, 2*).



Add Records

Add records for POP_91 and POP_81 for each district as shown.

District Name	POP_81	POP_91
Sindhupalchok	232326	261025
Kavre	307150	324329
Lalitpur	184341	257086
Kathmandu	422237	675341
Bhaktapur	159767	172952
Nuwakot	202976	245260
Dhading	243401	278068
Rasuwa	30241	36744

To do this,

- use Start Editing from the Table menu,
- in the Edit menu, choose Add Record,
- select Edit tool button to update the values in cell, and
- add the values for POP_91 and POP_81.

Calculate Values

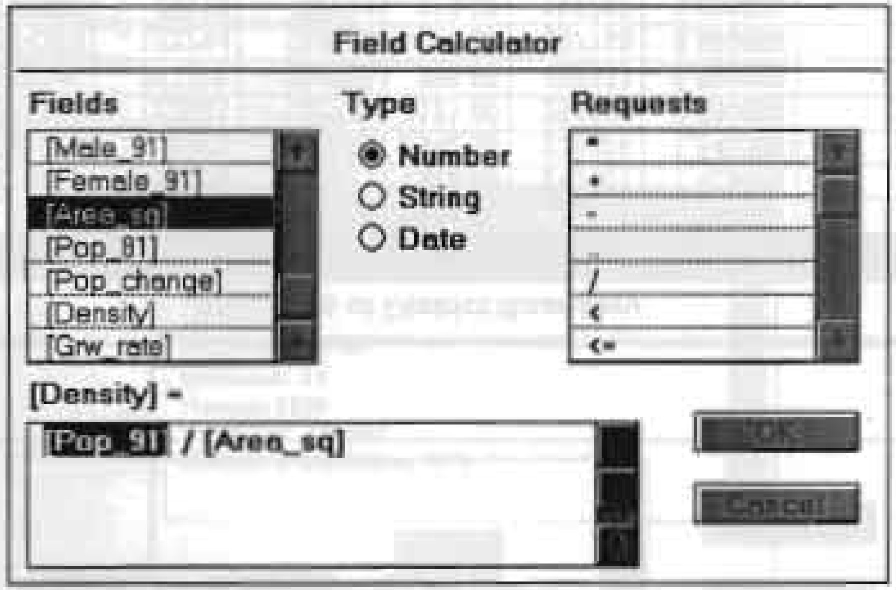
Open the attribute table for District by selecting Table from the Theme menu.

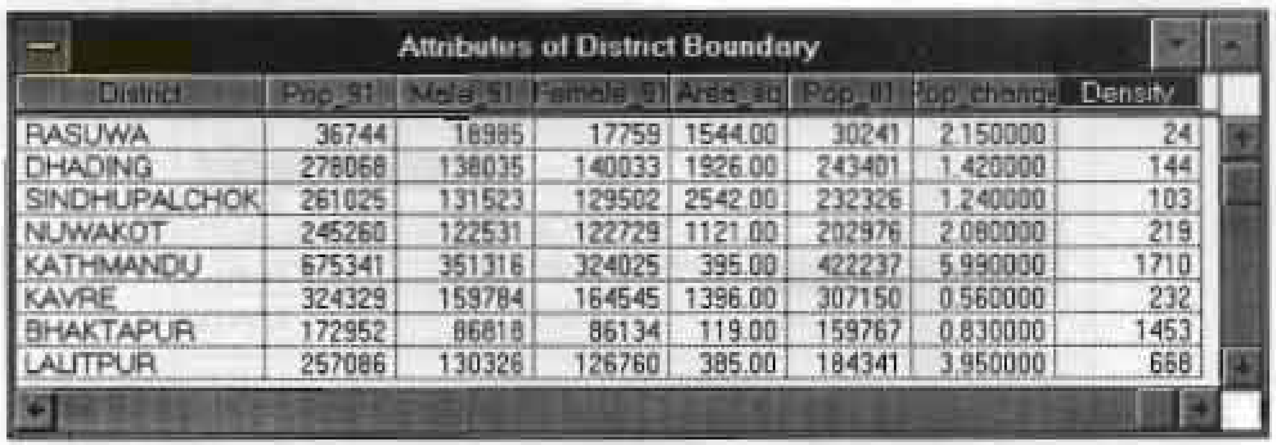
- Use Start Editing from the Table menu.
- In the table, activate the field DENSITY by clicking on it.
- Use Calculate from the Field menu.

The Field Calculator menu appears. Define the formula for density (pop_91/area_sq) in this menu.

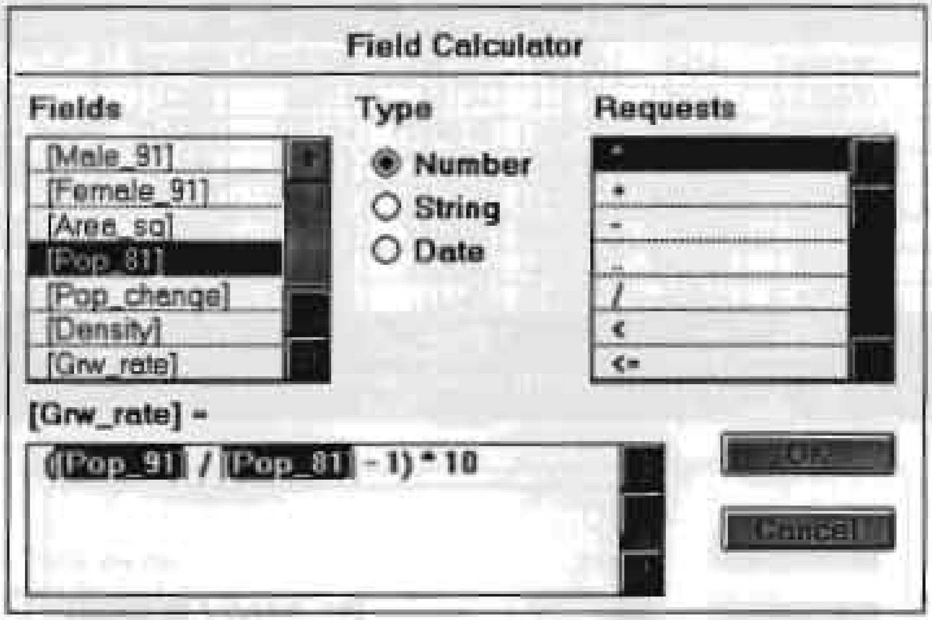
- Select area_sq (area in square kilometres) from the fields.
- Select division operator (/) from the Requests box.
- Select pop_91 from the Fields' box.

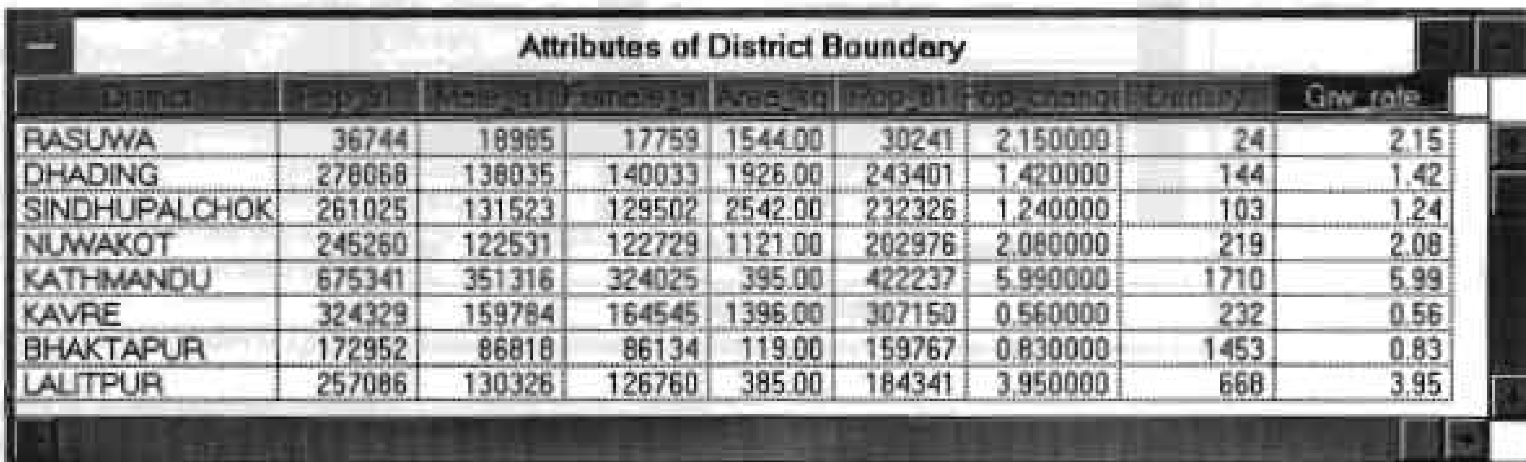
- To calculate density, activate the DENSITY field by clicking on it.
- Define the formula ([pop_91/pop_81 - 1]* 100) in the Field menu.
- Press OK to see both the results.





District	Pop_91	Male_91	Female_91	Area_sq	Pop_81	Pop_change	Density
RASUWA	36744	18985	17759	1544.00	30241	2.150000	24
DHADING	278068	138035	140033	1926.00	243401	1.420000	144
SINDHUPALCHOK	261025	131523	129502	2542.00	232326	1.240000	103
NUWAKOT	245260	122531	122729	1121.00	202976	2.080000	219
KATHMANDU	675341	351316	324025	395.00	422237	5.990000	1710
KAVRE	324329	159784	164545	1396.00	307150	0.560000	232
BHAKTAPUR	172952	86818	86134	119.00	159767	0.830000	1453
LALITPUR	257086	130326	126760	385.00	184341	3.950000	668





Attributes of District Boundary

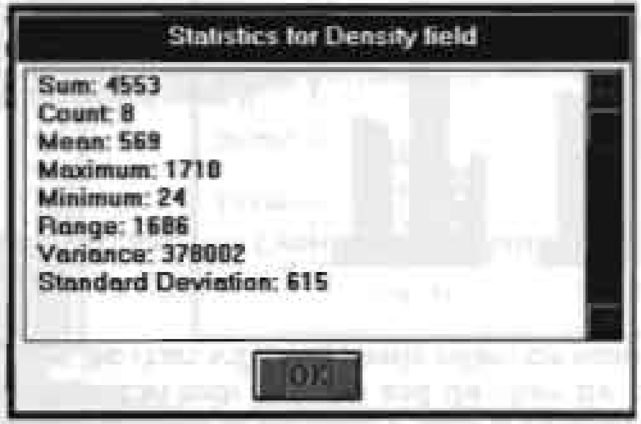
District	Pop_91	Male_91	Female_91	Area_sq	Pop_81	Pop_change	Density	Grw_rate
RASUWA	36744	18985	17759	1544.00	30241	2.150000	24	2.15
DHADING	278068	138035	140033	1926.00	243401	1.420000	144	1.42
SINDHUPALCHOK	261025	131523	129502	2542.00	232326	1.240000	103	1.24
NUWAKOT	245260	122531	122729	1121.00	202976	2.080000	219	2.08
KATHMANDU	675341	351316	324025	395.00	422237	5.990000	1710	5.99
KAVRE	324329	159784	164545	1396.00	307150	0.560000	232	0.56
BHAKTAPUR	172952	86818	86134	119.00	159767	0.830000	1453	0.83
LALITPUR	257086	130326	126760	385.00	184341	3.950000	668	3.95

View Statistics

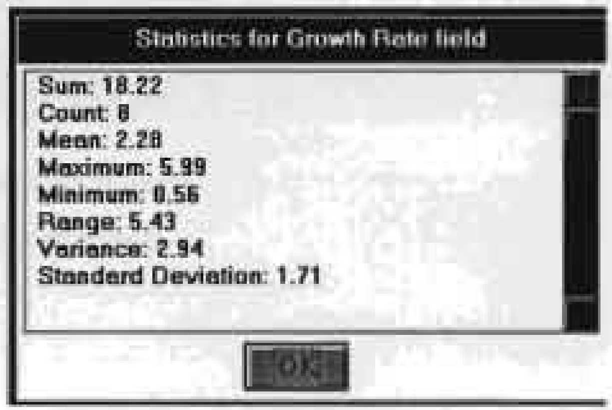
Now, you may want to view the statistics of fields that you have just calculated. To view the statistics of *Density*,

- open the attributes table for District,
- activate the field Density by clicking once on it, and
- select Statistics from the Field menu.

This will give the statistics of the field Density as shown.



Similarly, view the statistics of the field *Growth Rate* which should look as shown below.



Chapter 3

CHARTS: Visualising and Querying Data

What Is a chart ?

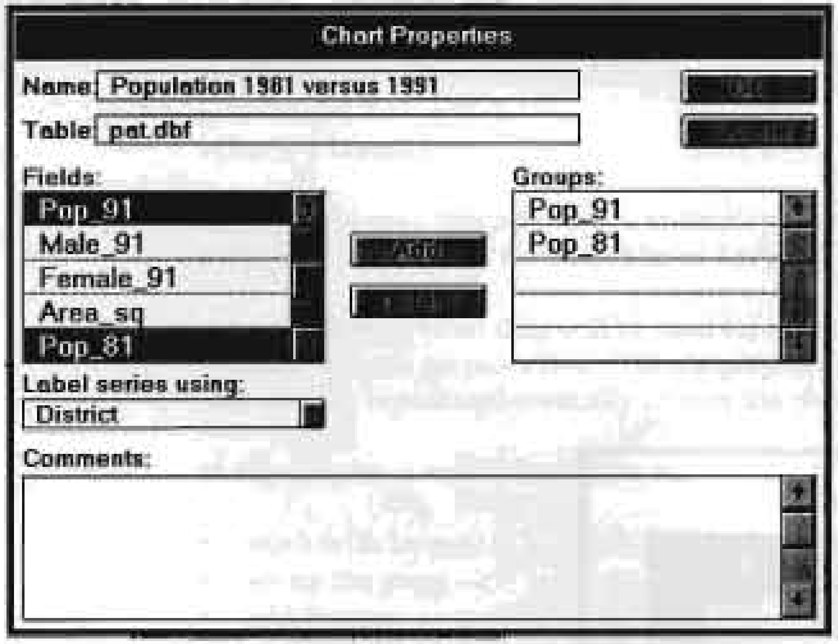
A chart is a graphic presentation of tabular data that provides a powerful additional visual representation of the attributes associated with geographic features. You can use a chart to display, compare, and query your geographic and tabular data effectively. Charts are fully integrated into ArcView's geographic user interface.

A chart references tabular data in an existing ArcView table in your project and defines how it will be displayed. A chart is dynamic, because it reflects the current status of the data in the table. If there is a change in the source data on which the table is based, this change will automatically be reflected in both the table and the chart the next time you open the project file that contains them. If you edit the table in ArcView, the chart will immediately reflect the editing.

Example 1 **Create a Chart to View the Population in the 1981 and 1991 Census of Each District of Bagmati Zone.**

To create a chart:

1. click on the table for District to make it active and open it,
2. choose Chart from the Table menu or the Create Chart button on the button bar to open the Chart Properties dialog box,
3. in the Pick a Table window, choose the *attributes of District boundary* table,
4. in the Chart Properties dialog box, select the fields (pop_81 and pop_91) that you want to plot on the chart and the field you want to use to label the data series, and
5. if desired, modify the data plotted on the chart and the look of the chart.



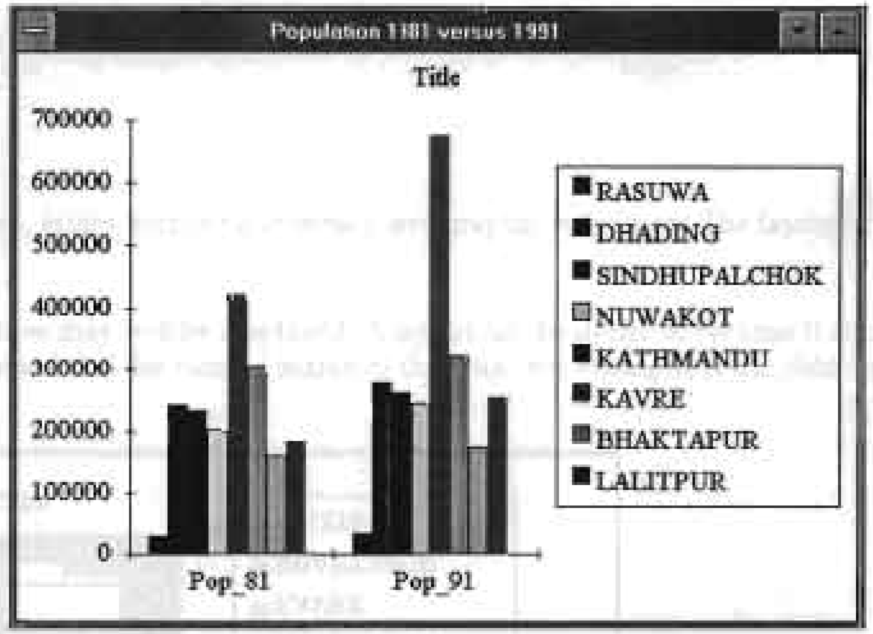
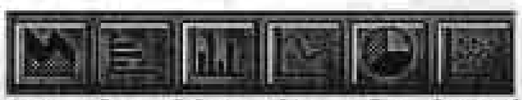


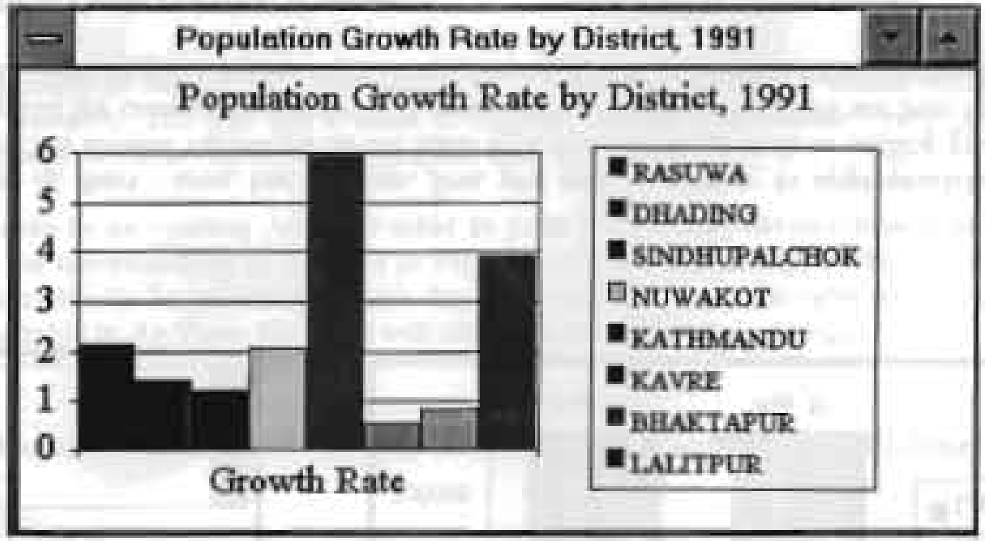
Chart Types

ArcView provides six types of chart - area, bar, column, line, pie, and xy scatter- to appropriately display different kinds of information. Each chart type has several variations on the basic type to select from such as adding gridlines or exploding the first pie slice. Some charts are good for comparing values and representing trends and others are best for emphasising a significant element. Choosing a suitable chart format for your data allows you to present your information more effectively.

Press the buttons for the type of charts you want to create.



Example: **Create a Graph to Show the Trend in Population Growth Rate by District, 1981 - 1991.**



LAYOUTS: Producing Maps

What is a layout ?

A layout is a map that allows you to display views, charts, tables, imported graphics, and graphic primitives. The layout is used to prepare these graphics for output from ArcView.

A layout defines what data will be used for output and how they will be displayed. A layout can be dynamic because it allows you to make specific graphics live. When a graphic is live, it reflects the current status of the data. For example, if the data in a view changes, the layout automatically reflects the change.

In this chapter, you will learn how to:

- work with layouts in a project,
- set up the page,
- add frames,
- add scale bars and north arrows, and
- add graphics and text.

Working with Layouts in a Project

An ArcView project can contain any number of layouts.

To See which Layouts Are in a Project

Click on the Layouts' icon in the Project window. The layouts in the current project are shown in the list.

To Create a New Layout

With the Layouts' icon selected, click the New button at the top of the Project window. ArcView creates a new layout and its name will appear in the list of layouts in the project. ArcView names new layouts in numerical order: Layout1, Layout2, Layout3, etc. See the Overview for creating a layout. You can also double click the Layouts' icon to create a new layout.

To Open a Layout

Double click the layout's name in the list of layouts in the Project window, or select the layout's name and click the Open button.

To Close a Layout

From the File menu, choose Close, or click the close option on the layout's window (This option varies according to the GUI you are using).

To Rename a Layout

Click once on the layout in the list in the Project window and choose Rename from the Project menu. A layout's name is also a layout property you can edit.

To Save the Work You Do with a Layout

In ArcView, you save the work you do with any project component by saving the project. To save your project, choose Save Project from the File menu or click the Save Project button in the Layout button bar.

To Copy a Layout from One Project to Another

If you want to copy a layout from another project into your current project, you should import the other project into your current one using Import in the Project menu. This will copy all the components of the other project into your current project. You can then delete the components that you do not require using Delete from the Project menu.

Defining the Layout Page

When you want to create a map using a layout, you will need to define some characteristics of the layout page. These include page size, page units, orientation, and margins.

Page size

There are a number of large and small format sizes provided by the default in ArcView. If you need a size other than these, you can use a custom page size and define its width and height. The default page size is derived from your printer.

Page units

Select page units from a list of choices. The default page units are inches.

Orientation

Choose between landscape and portrait orientation for the layout page. The default orientation is derived from your printer. If you change the orientation, any new layouts will use the new orientation as the default.

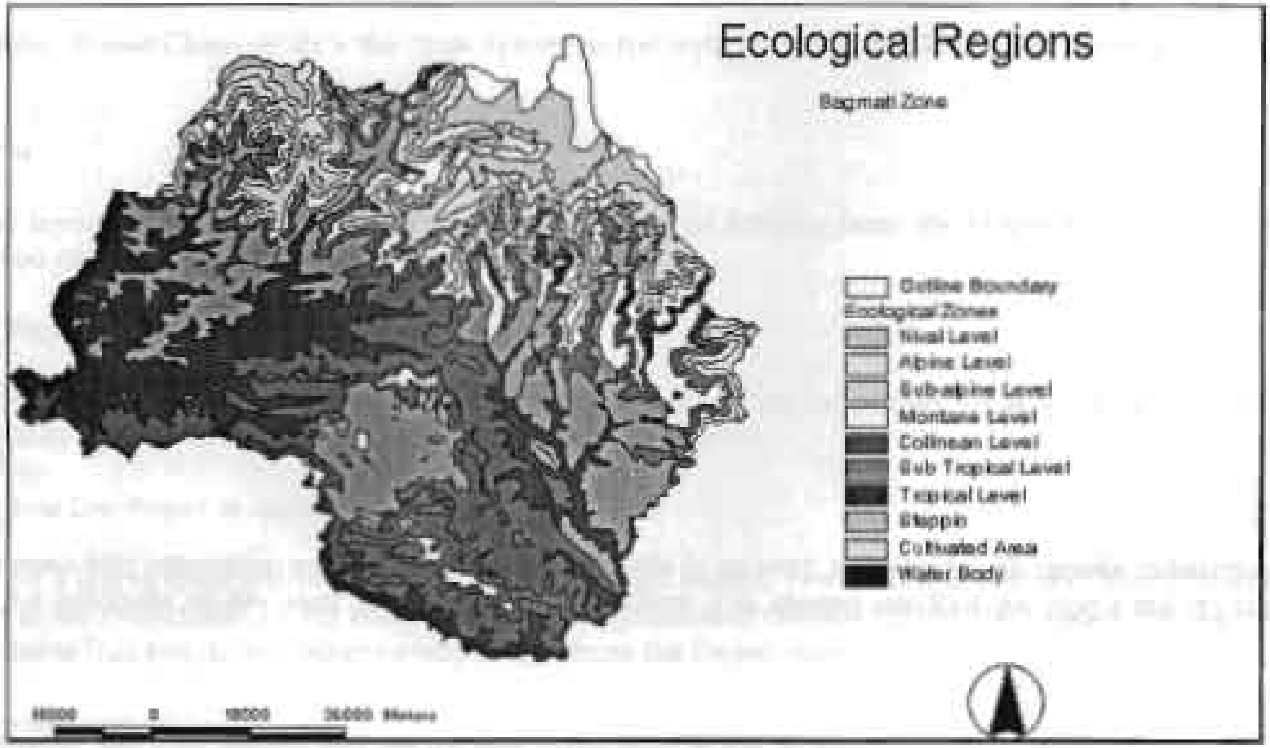
Margins

Define margins for the page or use your printer's default margins. The default margins for UNIX are .25 inches. The default margins on Windows and Macintosh are at the border of the page (0 inches), this value may change depending on your default printer.

Output resolution

Define the resolution the layout is printed and exported at.

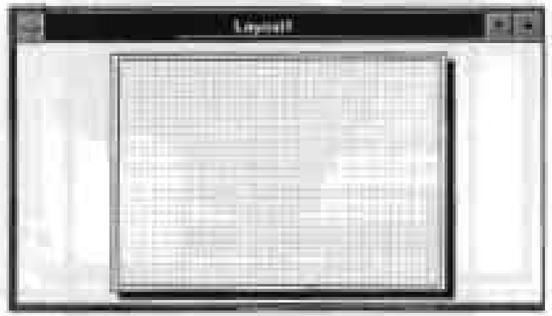
Exercise: In this Exercise, You will create a Layout Map of Ecological Regions of the Bagmati Zone as shown below.



Note: Before you proceed, make sure to set up the map units and the distance units of the view to metres as described in chapter 1 of this manual.

Create a New Layout

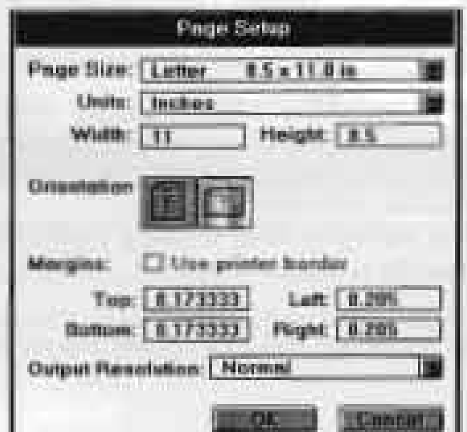
- Select the Layout icon from the Project window.
- Click the new button at the top of the Project window.
- ArcView creates a new layout.



Set-up Page

When you want to create a map using a layout, you will need to define some characteristics of the layout page. These include page size, page units, orientation, and margins.

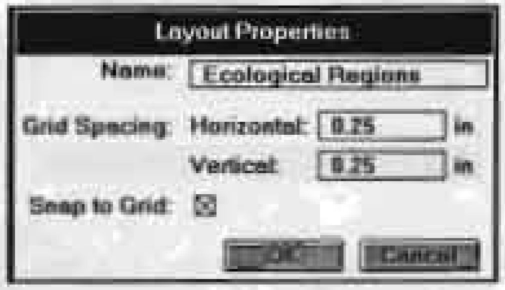
- Select Page Set-up from the Layout menu.
- Set up the page size = Letter 8.5 x 11.0 inches, page units = inches, width = 11, height = 8.5, orientation = landscape, and margins (top/bottom = 0.17; left/right = 0.2).



Define Layout Properties

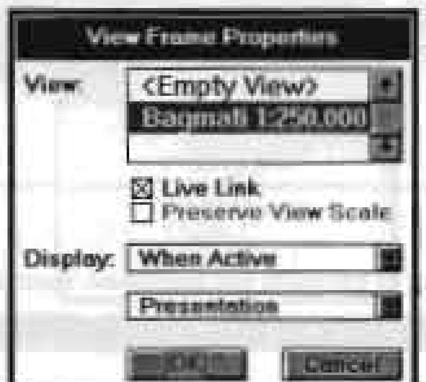
Before creating the layout, it is a good idea to define the layout that you are going to create.

- Select Properties from the Layout menu. The Layout Properties' window appears.
- Since you are going to create a map of the Ecological Regions, type *Ecological Regions* in the Name box and press OK.

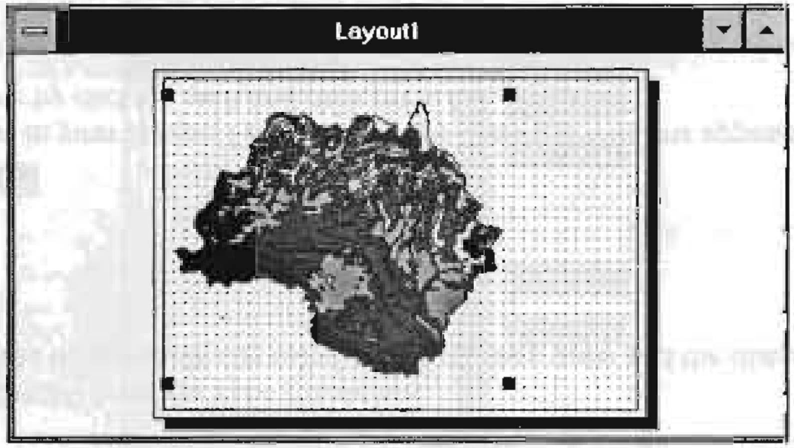


Add View

- Make sure that the theme *Ecological Regions* is displayed in the view.
- Now, to add this view into your new layout, click the view button . The shape of the cursor becomes +, use this cursor to define the area (make a box) to be plotted in the view in your new layout. After you define the area, the view frame properties' window appears

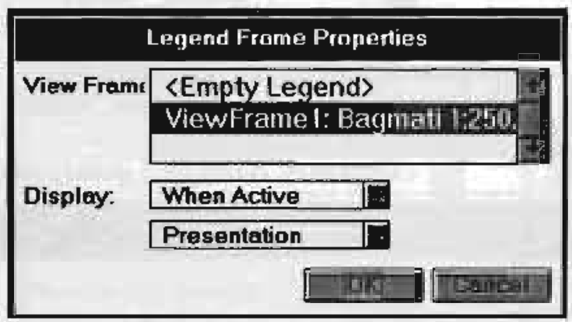


- Select *Bagmati 1:250,000* (the name of your project) from the View box and press OK. The map is displayed in your layout.



Add Legends

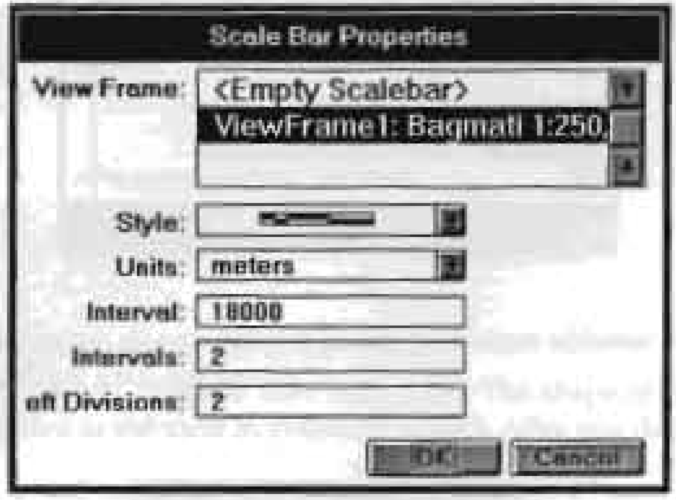
- Select the legend button by clicking the view button.
- Define the legend area (making a box) in the layout. Legend Frame Properties appears.



- Select the ViewFrame1: Bagmati 1:250,000 from the View Frame box and press OK. The legends are displayed in your layout.

Add Scale Bar

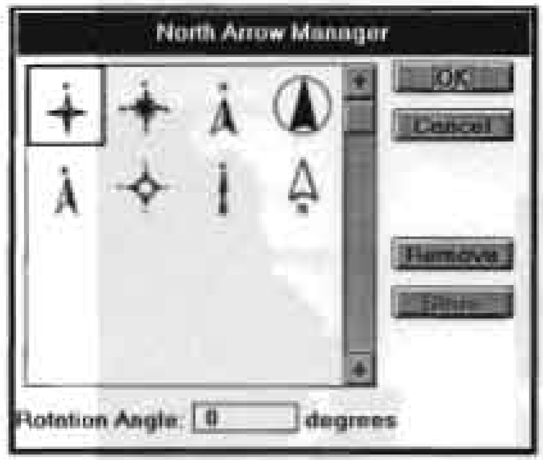
- Select the the scale bar button.
- Define the area for the scale bar in your layout. The Scale Bar Properties' window appears.



- Select ViewFrame1 Bagmati 1:250,000 from the View Frame box.
- The Units and Interval box should be automatically calculated if the map units and the distance units are set up properly.
- Press OK.

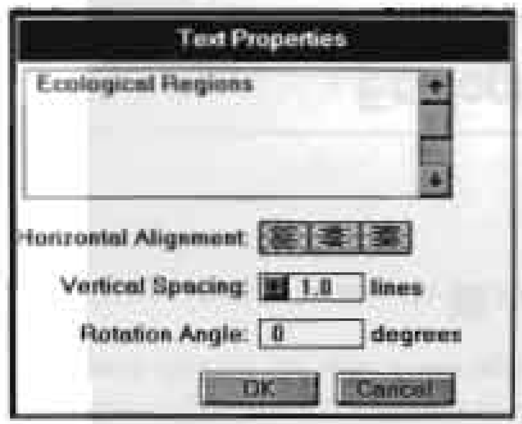
Add North Arrow

- Select the North Arrow button
- Define the area for North Arrow in your layout. The North Arrow Manager window appears.
- Choose a symbol for north arrow by clicking on it and then press OK.



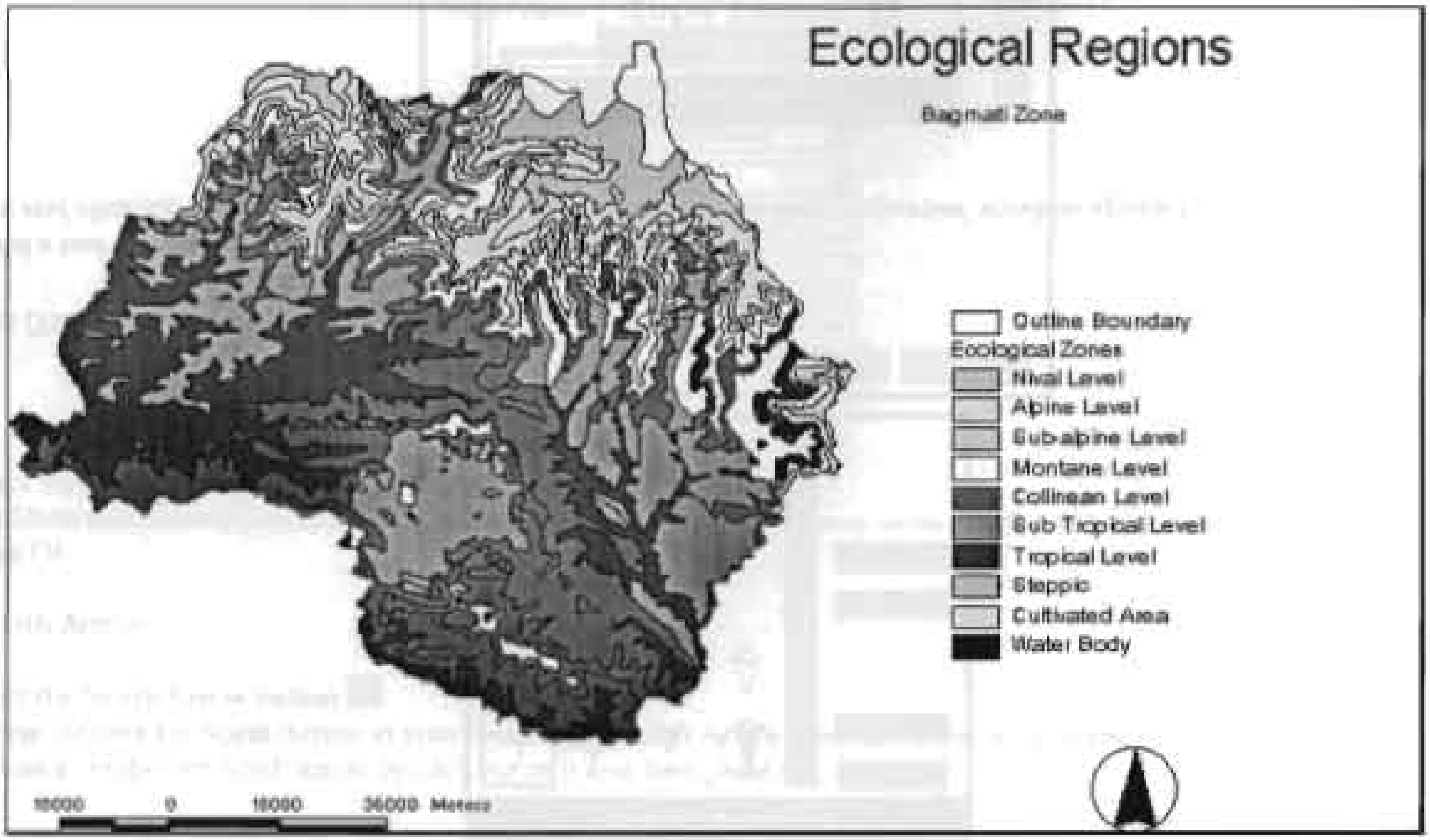
Add Text (Titles and sub-titles)

- To add a text for the title of the map, click the text button.
- Move and click the cursor where you want to place your title. The Text Properties' window appears.



- Type text Ecological Regions as the title of your map. Repeat the same process to add other text.
- To resize your text, select the cursor button and click on the text. A box appears around the text. Then resize the box to resize your text.
- To move your text or any other elements of your layout, click on it using the button. Move the box by dragging it.

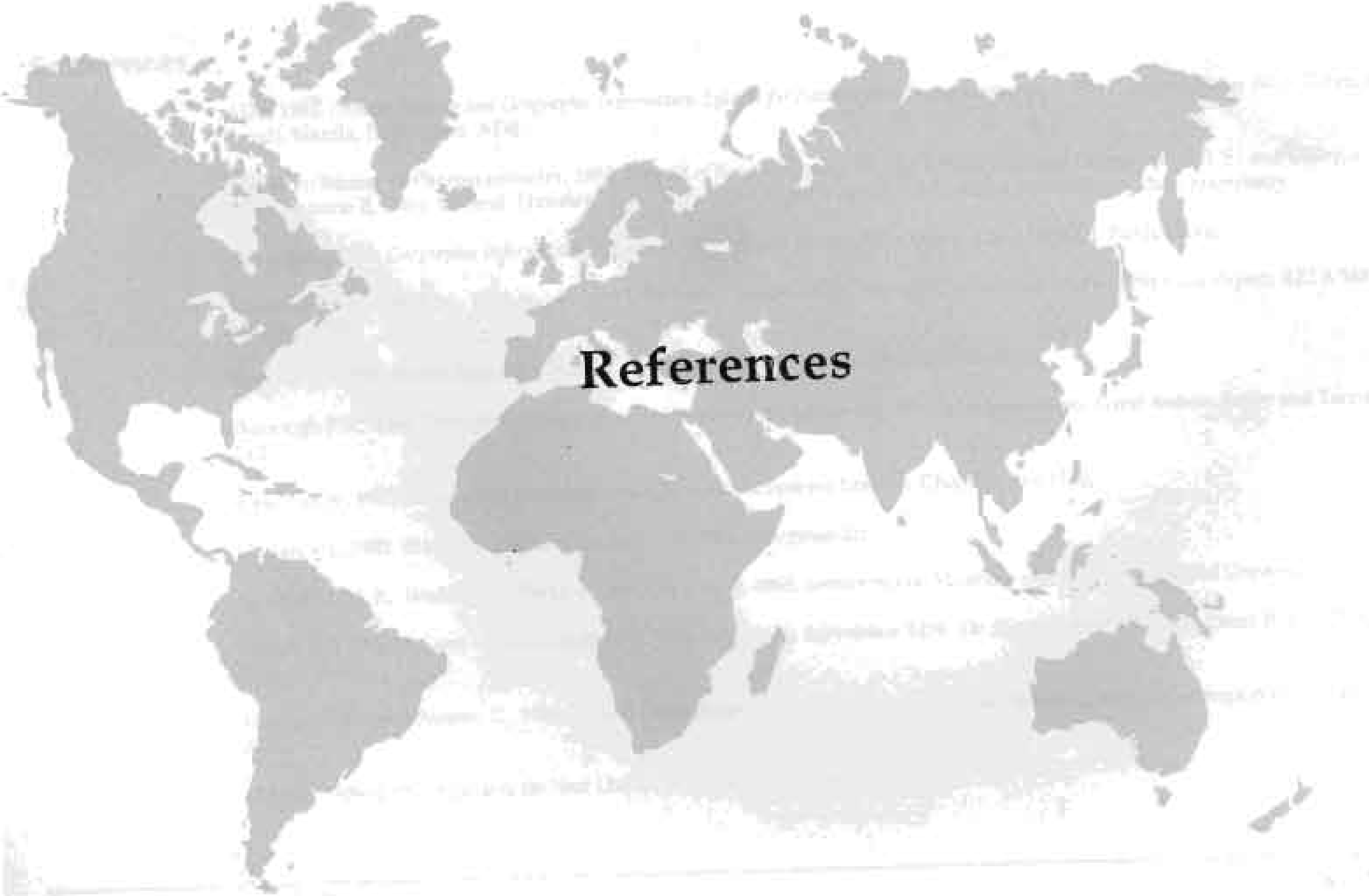
Now your final map layout should look like this.



Printing

Finally to print your map layout, select Print from the File menu.

Note: Before using **Print**, you may have to use the **Print Setup** to configure your printer, if it is not already configured.



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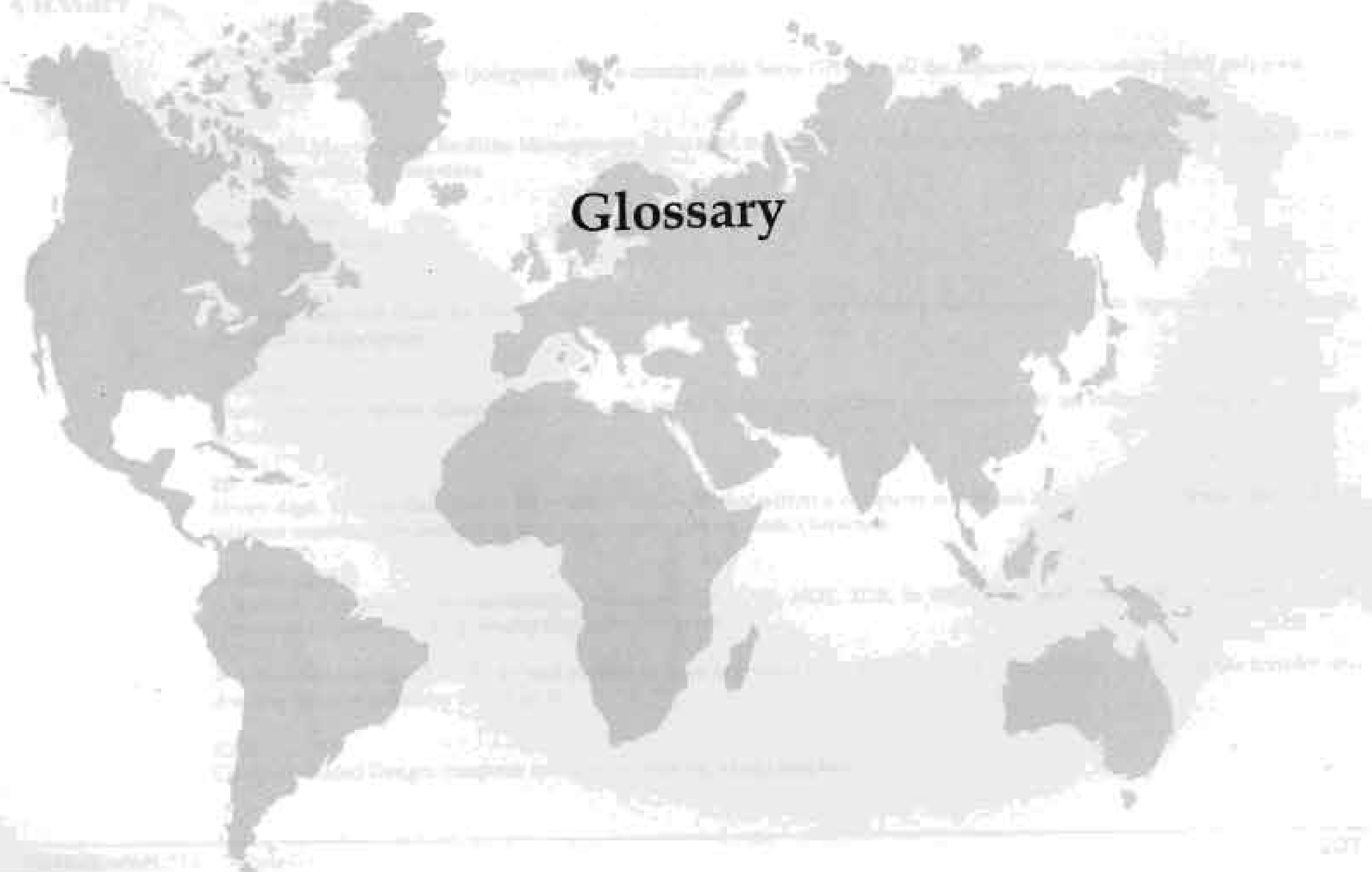
Glossary



Adjacency
Describes whether two areas (polygons) share a common side. Some GIS store all the adjacency relationships for all polygons.

AM/FM
Automated Mapping and Facilities Management. Term used to describe the digital mapping systems used in utilities such as water or electricity supply companies.

Analogue maps
Maps in paper form.

ASCII
American Standard Code for Information Interchange: a widely used industry-standard code which represents alphanumeric characters in a computer.

Attribute
Non-spatial descriptive characteristic of a real-world phenomenon. Often a measurement or value associated with spatial locations.

Bit
Binary digit. The smallest unit of information representation within a computer which can be set to 0 or 1. Seven bits have 128 different combinations and can be used to represent alphanumeric characters.

Boolean algebra
A method of specifying set combination operations: OR, AND, NOT, XOR. In GIS the sets are composed of geometry and the operations specify how the geometry should be combined.

Buffer
A corridor of a specified width defined parallel to lines or around polygons. Buffering is the process of defining the corridor and drawing the new geometry to delimit it.

CAD
Computer Aided Design: computer systems for drawing design graphics.

CCD
Charge Coupled Device: a device used in scanners to sense light/dark or colour contrast on a scanned map.

Choropleth
Map shaded by a density according to value.

Connectivity
Describes whether sets of points (nodes) or lines are connected to each other.

Coordinate pair (X, Y)
A pair of coordinates describing the location of a point feature on x and y axes. Sets of coordinate pairs are used to define lines and polygons.

Coordinate system
A particular type of reference frame, often grid-based, that uses linear or angular quantities to designate the position of points within the frame of reference.

Coverage
A collection of data describing spatial features stored in the same map file (primarily used by ESRI in ARC/INFO systems).

CPU
Central Processing Unit: the part of the computer that controls the flow of data and performs the computations.

CRT
Cathode Ray Tube: similar to a television picture tube, on which an image is displayed.

Cursor
The hand-held, movable part of a digitiser with cross hairs in a small window used for the accurate designation of points on an image or map.

Database
An organised, integrated collection of data related by a common fact or purpose.

Database Management System (DBMS)
A collection of computer software for organising and accessing the information in a database.

Data capture
The encoding of data or the conversion of map data to digital data, both spatial and non-spatial aspects.

Data dictionary
This contains information about definition, structure and usage of data in a database. No data is actually held here.

Data model
An abstraction of the real world which incorporates only those properties thought to be relevant to the application in hand. Also, a set of guidelines for the representation and logical organisation of data in a database, consisting of named logical units of data and the relationships between them. In GIS, this term usually refers to a set of spatial features with associated characteristics.

Data quality
The quality of the data measured in relation to the actual phenomenon measured at source.

Dataset
A named collection of logically related features arranged in a prescribed format.

Data structure
Detailed and low-level descriptions of spatial storage structures and the operations possible upon them.

DEM
Digital Elevation Model: a digital representation of a surface as a regular grid of elevation values.

Digital map data
A collection of digital information about real-world spatial phenomena.

DTM
Digital Terrain Model: a digital representation of ground surface relief enhanced by the addition of topographic information.

Digitiser
A device (usually electronic) for coding point locations on a graphic image or map to plane (x, y) coordinates.

DOS
Disk Operating System: the software which controls the transfer of data between main memory and disk. MS-DOS™ is the most common form of operating system for personal computers.

Edge matching
The comparison and adjustment of features to obtain agreement along the edges of adjoining maps.

Editing
Inserting, deleting and changing geometry and attributes to correct and/or update a model or database.

Electro-magnetic spectrum
The spectrum of wavelengths of electromagnetic radiation (including infrared, visible, and ultraviolet light).

Electrostatic printer/plotter
A device for printing graphic images by placing a grid of small electrical charges on the paper so that a dark or coloured powder, or toner, will adhere to these places.

Entity
A real-world phenomenon perceived or perceivable by human agency.

Error
Various forms of discrepancy between real-world phenomena and a database. Error can be introduced into a spatial database during capture and processing.

Feature
A real-world phenomenon, named and classified. Often used in cartography to name classes of elements shown on a map.

Feature code
An attribute specifying the type of feature recorded in a GIS. Cartographic agencies define feature codes to standardise the description.

Field
A subdivision of a record which contains a unit of information. A characteristic measure for all records.

File
A collection of records, each of which can be referenced according to its position in the file.

Filtering
A method of changing the level of detail or extraction of information from a spatial (normally raster) dataset.

Generalise
Reduce in detail, simplify or resample to change the level of information in a dataset. The most common generalisation operation is line-thinning by discarding coordinates.

Geographic information
Information which can be related to a location (defined in terms of point, line, and area), particularly, information on natural phenomena, cultural or human resources.

Geographical Information System (GIS)
- a set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of circumstances (Burrough 1986)

Geometry
A system for the manipulation of points and lines defined by a set of axioms.

Global Positioning System (GPS)
A GPS is a position-fixing system which uses the time taken for signals to travel from at least three GPS satellites in a known orbit to a receiver on the ground.

Hardware
The physical device used to process a computer programme and display the results.

Heads-up digitising
Heads-up digitising systems automatically convert strips of raster pixels to vector data by tracing them on screen

Image processing
Encompasses all the various operations that can be applied to image or raster format data. These include image compression, restoration, enhancement, rectification, preprocessing, quantisation, spatial filtering and other image pattern recognition techniques.

Ink-jet printer/plotter
A display device that prints out characters and grey tones as patterns of small dots formed by tiny drops of ink sprayed onto the plotting medium.

Interactive
Describes a process of two-way communication between the user and the computer.

Interface
An electronic translator of the signals of two devices, such as a computer and a plotter, so that otherwise incompatible information can be transferred between them; or a screen format for the display and communication of commands to the computer.

Interpolation
The procedure for estimating the values of unknown points on a surface from the values of a number of points of known value.

Isoline
A line joining points of equal value.

Isometric models
A model of a scene or object scaled to reality.

KBS
Knowledge Based System: a system based upon rules, defined and structured for use in making inferences in restricted knowledge domains.

LAN
Local Area Network: a network linking computers together in a small area (usually a single building).

Layer
Usually represents a theme or feature type within a database. Layers which are registered to the same coordinates as other layers can be integrated in different ways to create a new layer.

Line
The shortest distance between two points (sometimes called a line segment). In some GIS, many connected line segments are also referred to as a line. A one-dimensional object.

LIS
Land Information System: a system for handling land ownership (cadastral) data.

Map algebra
A set of operations for manipulating, filtering, and combining raster maps devised by Tomlin and used in many GIS.

Map projection
A transformation from a spheroid to a flat plane representing the parallels of latitude and the meridians of longitude of the earth.

Menu
A list of available options displayed on a terminal or a set of preprogrammed areas on a digitiser.

Mouse
A device used to move a screen cursor and to input commands; commonly used in graphical operations.

Network analysis
Analytical techniques concerned with the relationships between locations on a network, capacities of network systems and the best location for facilities on a network.

Object-oriented programming
Object-oriented programming is a language design which has been used to develop database management systems and application programmes such as GIS. Object-oriented software has data 'encapsulated' with operations, and commands are executed using message passing.

Overlay
The process of integrating digital representations of various spatial data registered to a common coordinate system.

Pixel
Short for Picture Element, i.e., the smallest discrete element that makes up an image. It may represent either a small square or portion of the earth's surface, scanned by satellite or aircraft, a portion of a graphics image sensed by an optical scanner or an individual dot on a screen.

Point
The position or location of an object in a spatial reference system. A zero-dimensional object.

Polygon
An area with three or more sides intersecting at the same number of points. A two-dimensional object.

Projection
The procedure for transferring features from the spherical earth to a flat plane using mathematical transformations.

Quadtree
A structure to compress and spatially index raster data. Constructed by dividing an (square) area of data recursively until a quadrant is completely full or empty.

Query
A structured enquiry made on a map or database using formal language.

Raster data
Data expressed as an array of pixels with the spatial position implicit in the ordering of the pixels.

Rasterisation
The process of converting vector data into raster form.

Record
A set of observations on real-world phenomena as described by attributes.

Relational database
A database of tables which can be linked together through common attributes.

Remote sensing
The technique of obtaining data about the environment and surface of the earth from a distance, e.g., from an aircraft or satellite.

Resolution
Level of discrimination in the representation of objects, generally spatial.

Scale
The ratio or fraction between the distance on a map, chart or photograph and the corresponding distance on the surface of the earth.

Scanner
The electronic device used to convert analogue information from maps or images into a digital format usable by a computer.

Scanning
A method of data capture whereby an image or map is automatically registered and converted into digital raster form.

Sliver polygon
Formed when two polygons which have been overlaid do not abut exactly but overlap along one edge and leave a small space between the two.

Software
A system of programmes used to execute tasks written for the computer.

Spatial analysis
Analytical techniques associated with the study of locations of geographical phenomena together with their spatial dimensions.

Spatial data
Data relating to the location of geographical phenomena together with their spatial dimensions.

SQL
Structured Query Language: a language for the manipulation, update and querying of the data in relational database tables. ISO standard 9075 (1987).

Standards
A fixed quantity or quality, applied to data. Standards serve as a reference or rule and establish practices or procedures to evaluate results.

Terrain modelling
The creation of a realistic terrain representation for computer display.

Tessellation
The subdivision of geographic space using either regular or non-regular methods.

Thiessen polygon
A polygon bounding the region closer to a point than to any other adjacent point.

Tile
A regular- or irregular-shaped spatial unit within a geographical database.

TIN
Triangular Irregular Network: the most equilateral set of triangles possible joining a set of points.

Topographic map
A map showing the features which describe the surface of a particular place or region.

Topological structuring
The process of organising data so that the relationships of connectivity, adjacency and containment are encoded and stored.

Topology
The location of geographic phenomena relative to each other but independent of distance or direction. Includes relationships of connectivity, adjacency, and containment.

Transformation
Mathematical conversion of coordinates between alternative referencing systems. Affine transformations keep straight lines straight, and curvilinear ones may make straight lines curved (e.g. as in map projection).

Triangulation
The interconnection of all points within an area to form a set of reproducible triangles.

UNIX
An operating system of software used commonly for workstations.

Variable
A discrete measurement on a parameter.

VDU
Visual Display Unit: a screen display for a computer.

Vector data
A description of spatial phenomena based upon geometry.

Vectorisation
The process of converting raster data into vector form.

Window
A frame with a specified size and location on the screen of an interactive graphics system and within which a rectangular portion of the 'map' is displayed.

Work station
A powerful computer with integral processing and data storage and a high resolution screen.

Appendices

Appendix A

ArcView - The Ultimate Window to Spatial Data

Environmental Systems Research Institute, Inc. ARC News, Reprint, Spring 1991 Issue, Vol. 13, No.2 [Reference/Reprint]

The benefits of using GIS are now widely understood by most organisations that use spatial information. Despite this awareness, the actual number of active users has remained relatively small. This is due in part to the fact that virtually all GIS technology currently available (from desktop to mainframes) requires, at least, basic GIS skills.

This is about to change. This month ESRI is introducing a completely new product called ArcView which provides a major breakthrough in the usability of GIS. ArcView creates a new user environment for geoprocessing by making it easy and fun for users to visualise, query, and analyse geographic information.

ArcView is an easy-to-use productivity tool derived from years of research and development efforts by ESRI that have gone into producing its ARC/INFO software. It is inexpensive and completely compatible with all the various types of data supported by ARC/INFO. These include vector coverages, tabular database management systems, surface models, grids, and a variety of raster images, including remote-sensing data and binary-scanned documents.

"ArcView will revolutionise the way we think about both mapping and GIS," said Jack Dangermond, ESRI president. *"People who are not familiar with GIS can sit down and use it right away with virtually no training. The software is based on simple ideas that allow users to learn to use it naturally and intuitively. They can learn simply by experimentation and be thoroughly competent in a matter of minutes to hours."* This will open up GIS to a whole new category of users, including managers, elected officials, students, the public, and a vast array of others who are not trained in GIS, but who have an interest in and use for geographic information.

"ArcView is not just GIS made simpler," continued Dangermond. *"It also introduces many new concepts for interacting with an electronic model of spatial reality. ArcView includes a variety of highly interrelated visualisation and query tools that can be used to craft a literally endless number of interpretations and view of geography. These views can be produced as soft copy publications for access across a network or output directly as hard copy with a variety of desktop-related devices. With the introduction of ArcView, GIS is moving from a tool to create applications to a front-end view of applications."*

Although the biggest impact of ArcView will be in making geographic information more accessible and usable to a wider range of potential users, ArcView was originally conceived of as a way to help ESRI's existing user community. This is where the new product will perhaps have its largest initial popularity. Both PC ARC/INFO and workstation ARC/INFO users will instantly be able to publish their data for casual query and display.

"ArcView will revolutionise the way we think about both mapping and GIS."

- Jack Dangermond, ESRI President

They will also be able to integrate ArcView into their application systems, allowing ArcView to function as the display and query module within certain types of application.

"The original idea for ArcView came from our existing users," explains Dangermond. "We learned that may of them needed a way to provide electronic access to their data for people who needed to access it, but could not afford the time to learn a complicated technology. Their option historically was to develop a custom application. With ArcView, the most valuable GIS concepts of ARC/INFO software are organised into a generic system that can serve virtually every user."

ArcView will run on PCs, Macintosh, and any of the UNIX platforms now supported by ARC/INFO. It operates as a stand-alone desktop mapping solution as well as in the role of a client on a client-server network.

As a stand-alone application, ArcView can be used by existing ARC/INFO users to provide copies of their data to other individuals and organisations. There are thousands of ARC/INFO users who have created tens of thousands of coverages around the world. ArcView will create an environment that promotes the publishing and sharing of their data.

The publishing environment will also take place across electronic networks. On a network, ArcView can be running on a user's existing desktop computer and be accessing and visualising ARC/INFO databases across the network without converting or transporting *any* data. In this sense, ArcView serves as an integrating technology bringing together all of the diverse desktop units into a shared GIS network.

Applications

ArcView will open up computerised mapping to a whole new world of users. Because it is so simple to use, ESRI envisions that ArcView will appeal to the following types of people.

- Specialists who only occasionally need to access geographic information and, therefore, do not have the time or the inclination
- to learn to use a comprehensive GIS
- ARC/INFO users who are using ARC/INFO for analysis and would like to use ArcView for quick and easy display and query
- Individuals who want a single desktop GIS that is totally integrated with a database
- ARC/INFO users who want to make data available to other departments, field offices, or other remote locations
- Private and public organisations that want to publish their data electronically for others to examine and access
- Managers who need an "at-a-glance" look at geographic data
- Organisations that want to present electronic interpretive maps
- Public agencies that can save staff time by making records available to the public who can access the data from a conveniently-located terminal
- Students in elementary, high school, and college, who can use mapping as a fun way to become geographically literate, as well as to improve their knowledge of computers
- The public who wants to enquire about their community and its data

How Does ArcView Compare with Other Desktop Mapping Systems?

ArcView is unique. There is no other solution that comes close to its unusual approach to organising and integrating geographic information. ArcView can be considered to be a stand-alone desktop mapping and GIS solution. In this capacity, it is far cheaper and far more functional than any competitive products. ArcView is also a network product and will have the capability of providing full integration between desktop computing users and large GIS repositories.

Beyond its architecture, ArcView has the additional benefit of being compatible with nearly one billion dollars worth of data that have been converted into the ARC/INFO format. There are thousands of ARC/INFO user organisations that have historically developed or are currently developing smart geographic databases that can be used immediately by ArcView users.

Major Features of ArcView

What are ArcView's features? In a nutshell, it provides the following capabilities.

Visualisation: tools including raster/vector display, pan and zoom, and multiple windowing

Map Legends: tools for easily creating user-defined legends and map classes

Spreadsheet: tools that fully integrate the functionality of a spreadsheet with the functionality of a GIS

Selection tools for spatially selecting a feature by pointing to it with the cursor or by creating a box, polygon, or circle around a set of features. Additional tools are used to manipulate and view attributes of their selections in a spreadsheet type of format

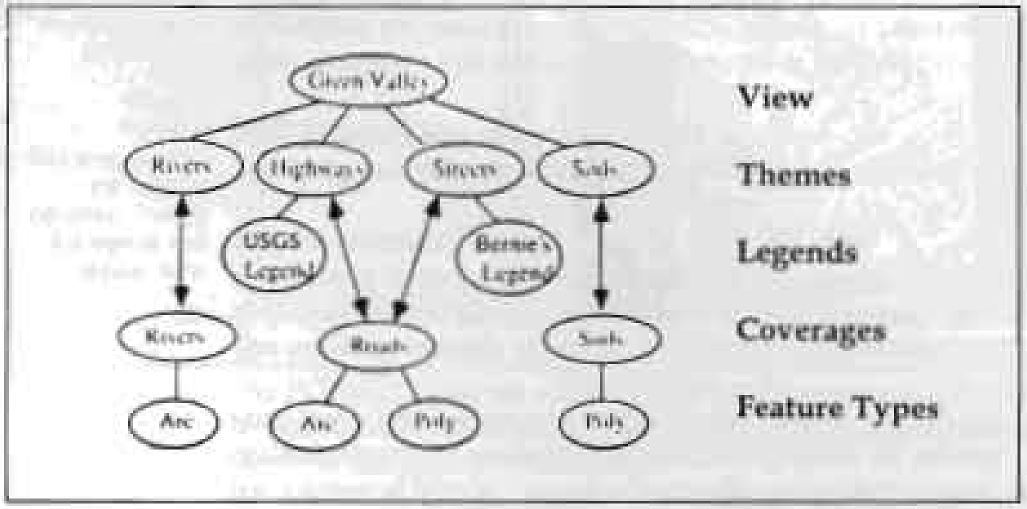
Logical manipulation: tools for logical modelling of tabular data with closely-integrated visualisation tools for graphic representation of the map model

Statistical tools: tools to calculate and summarise statistics about a geographic feature or set of features

Planning: tools that output hard-copy graphics on a host of ESRI-supported hardware devices, as well as tools for generation of industry-standard files, such as PostScript, for easy integration with other desktop applications

Because ArcView is an entirely new product, its design is based on a new approach to working with geographic information. This new approach builds a conceptual model of a user's perception of geographic data into the graphic user interface, resulting in a more intuitive approach to working with geographic data.

The View. The fundamental concept of ArcView is a view. A view is an organising principle for managing information about geography. Views are dynamic in that they can be updated and modified in the geographic database. Views can also be saved. This means that you can save a view, quit ArcView, then restore the view in ArcView some time later. You can also define multiple views of the same geographic database, a view can also be created from a variety of different data sources. A view is made up of a collection of *themes*.



The Theme. A theme is the representation of a geographic topic of interest. It can be derived from any one of several geographic data sources, including ARC/INFO coverages, image data, or GRID or TIN data. An ARC/INFO coverage can be represented as an individual theme, or several themes can be derived from a coverage representing various categories of features contained within a coverage. For example, you could derive the themes "highways" and "routes" from the coverage "roads" based on attribute information.

A theme also has an associated *legend*, which governs the rendering of features within the theme based on an attribute value. The simplest legend contains one symbol, with which every feature within the theme would be rendered identically. Another legend might contain many different symbols allowing symbolisation of features based on attribute value.

Legends. Legends are an organised set of symbols associated with some property of a theme. A legend is a table organised by a value or a range of values through which a symbol definition may be acquired. For example, a legend of road symbols published by the U.S. Geological Survey and organised by a minor attribute code could be used to render any feature that had corresponding values. That is, if a user had an arc feature with the attribute value "40005" and the feature was rendered using the USGS legend, it would be drawn with the symbology specified by the USGS for that value. If the user then wished to render the map adhering to another standard, a different legend could be loaded.

Table of contents. The *table of contents* is a graphic object with which the user interacts. The table of contents is used to organise the themes of a view. While it is not the view itself, it does reflect the view by listing the themes currently defined for the view, the display status of themes, and their symbology or legend. As the table of contents of a book reflects the contents of a book, ArcView's table of contents reflects the contents of the view.

The table of contents is not simply a static representation of the contents of a view, but an object that is manipulated interactively to facilitate view operations and theme manipulation. For example, adding and removing themes from the current view, changing the symbol or creating a legend for a given theme, or toggling a theme from "visible" to "invisible" is done by interacting with the table of contents.

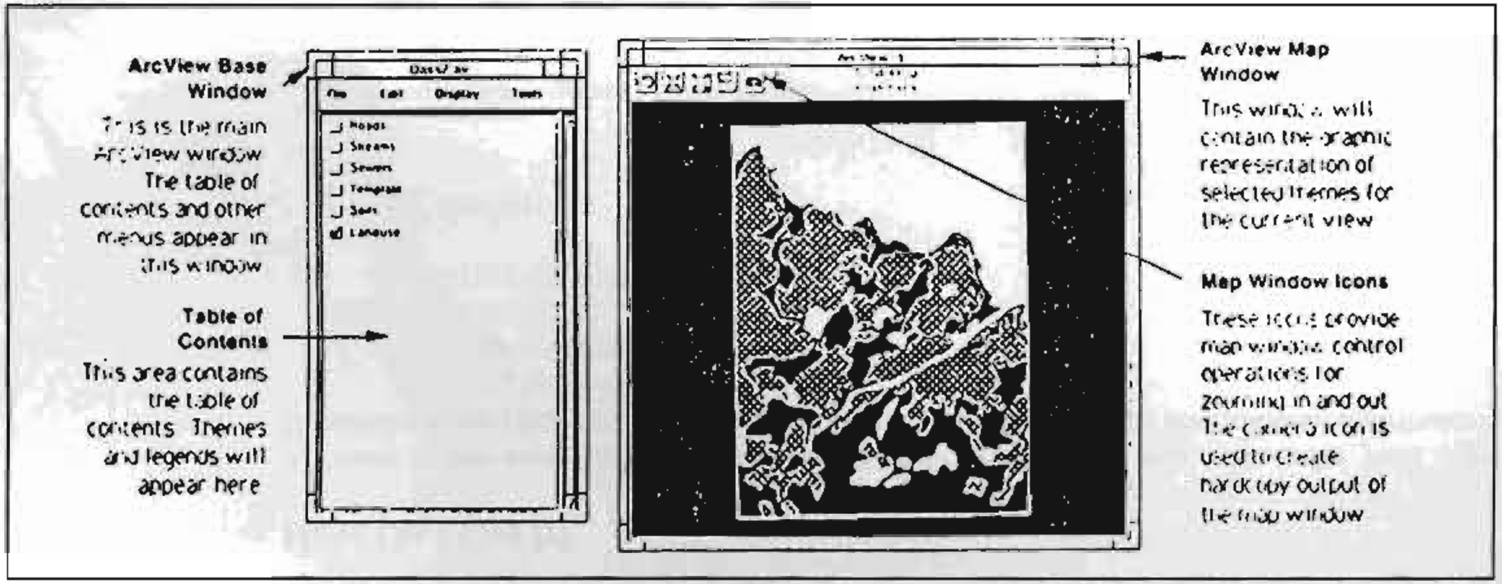
The ArcView interface incorporates two types of windows within the interface design. These windows are called the ArcView Map Window and the ArcView Base Window.

Map window. The *map window* is the main graphic canvas on which geographic features are rendered. It supports pan and zoom operations for control of spatial scene extent. It reports the current location of the screen cursor in the coordinate system of the view and indicates the coordinates of the current spatial scene extent. Like the table of contents, the map window also reflects the view. The themes specified in the table of contents control the contents of the map window.

Multiple map windows can be displayed for the current view. This allows you to have one window that may be used as a reference map, while other windows can be used to zoom in for a close-up view of specific areas, or even display different themes in different windows.

The map window provides tools represented in iconic form, with which spatial queries can be made.

ArcView Tables. Another window in which user interaction with themes can occur is each theme's table. This window displays the attribute information associated with the theme, and it provides tools with which to perform logical selection, generate statistics, and to save reports separately, etc.



Multiple Platforms and Data Compatibility

ArcView has been designed to address all of these requirements necessary for multiplatform support, data compatibility, and network intelligence. Because of new breakthroughs in user interface design tools, ArcView will be available on most of the platforms supported by ESRI that also support windowing environments. This means that ArcView will work on UNIX workstations, PCs, and there will even be a Macintosh version. The PC and Macintosh versions will be able to access ARC/INFO databases over a network or as stand-alone platforms. Also, because each of these platforms support windowing environments, ArcView will have a similar look and feel no matter what platform the user is working on.

Another significant operational breakthrough for ArcView will be its ability to be a 100 per cent data compatible across all platforms that support ArcView. This means that ArcView will "know" the binary structure in which ARC/INFO geographic data sources are stored on all supported platforms.

This data compatibility makes ArcView "network intelligent," that is, ArcView will be able to find and access supported data anywhere on a network. For instance, if you have ArcView running on your PC and your PC is on an Ethernet network of PCs and workstations, ArcView will be able to access your local data or data on any of the workstations on the network. If you have Macintoshes connected to the network, the Macintosh version of ArcView will also be able to access workstation data on the network. This capability will be supported on local area PC networks; workstation Ethernet networks; and mixed Ethernet networks having PCs, Macintoshes, and workstations.

Release Plan

ArcView is a completely new product for ESRI. It will be released in several phases on the UNIX workstation. The release plan provides a useful product to UNIX users this summer. The PC and Macintosh versions of ArcView will be released later in 1991.

How Do I Get It?

ArcView is the most affordable GIS data access tool you can buy. To order your copy of ArcView, call ESRI's Marketing Department (telephone: 714-793-2853), your regional office, or your international distributor.

Appendix B

PC-based GIS Hardware Configuration

A. Computers

486 DX2 66 MHZ / Pentium 60/90
8/16 MB RAM
500 MB or Harder Disk
1.44 MB Floppy Disk
SVGA 15" Monitor w/ 1 MB VRAM
Enhanced Keyboard
Mouse

Optional: CD-ROM / Multi-media Kit
Backup system: Streamer tape or Magneto Optical Disk Drive

Brand : Original Brand 113M/Compaq/AST/Dell etc.

B. Power System

600 VA - 1 KVA UPS
for each computer

Brand: AVC/Best or any other

C. Digitizers

A1 size Digitizer w/ 16 button cursor
Size could vary according to User's need
Brand: Calcomp / Summagraphics

D. Plotters

1. HP Designjet 250 C
2. HP Designjet 750C -A1 or A0 size

E. Printers

1. HP laserjet 4 M Plus Laser printer - up to A4 size
2. Tektronix Colour laser printer - up to A3 size

F. Scanners

1. HP Scanjet II c up to A3 size
2. High Resolution Colour Scanners

Tangent/Vidar/Microtec - up to A0 size

Appendix C

Software Used in MENRIS

ARC/INFO Version 7.0
ESRI, Redlands, CA, USA

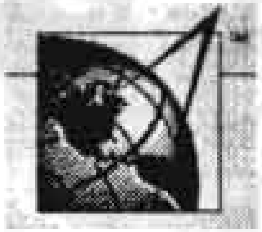
ERDAS PC 7.5
ERDAS, Inc. Atlanta

PC ARC/INFO 3.4.2
ESRI, Redlands, CA, USA

ILWIS 1.4
ITC, Netherlands

ARCVIEW 2.0
ESRI, Redlands, CA, USA

IDRISI Version 4.0
Clark University, Massachusetts, USA



ArcCAD
Release 11.3

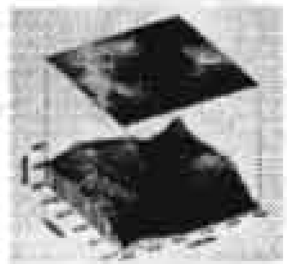
ESRI, Redlands, CA, USA

Map Viewer
Thematic Mapping for Windows

Golden Software, Inc. CO, USA

AutoCAD for Windows
Release 12

Autodesk,Inc. USA

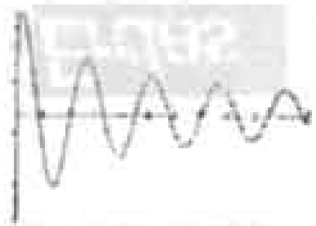


SURFER for Windows
Version 6.0

Golden Software, Inc. CO, USA

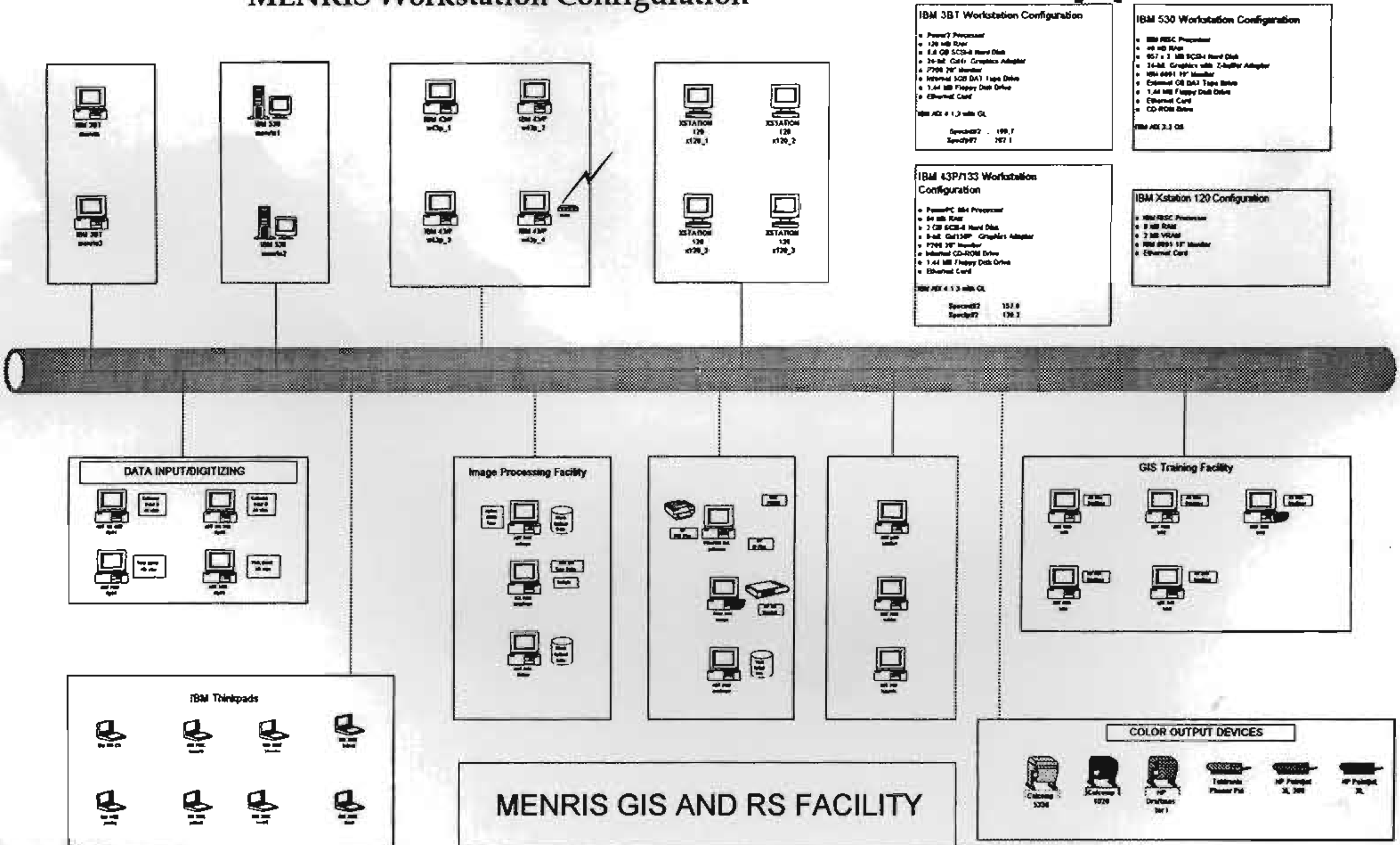
Structured Elevation Model
Version 1.3.0

ESRI, Germany



GRAPHER for Windows
Golden Software, Inc. CO, USA

MENRIS Workstation Configuration



Participating Countries of the Hindu Kush-Himalayan Region

- Afghanistan
- Bhutan
- India
- Nepal
- Bangladesh
- China
- Myanmar
- Pakistan

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